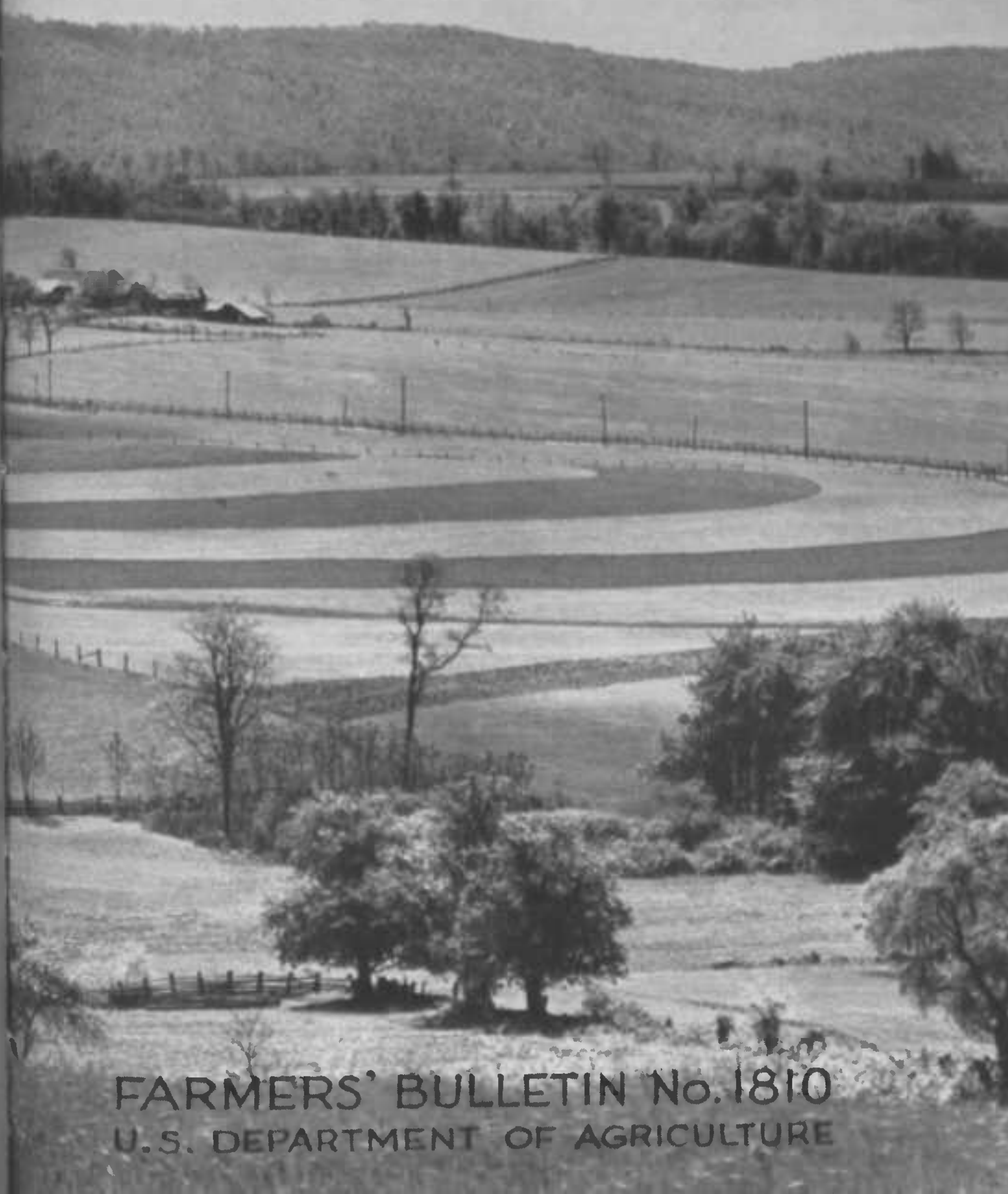
SOIL DEFENSE IN THE NORTHEAST



FARMERS' BULLETIN No. 1810

U. S. DEPARTMENT OF AGRICULTURE

FOREWORD

This bulletin treats of that part of the United States which is commonly referred to as the Northeast. The western boundary of the region here considered begins at the eastern edge of the Corn Belt in central Ohio. The Canadian line on the north, the Atlantic Ocean on the east, and the Virginia-North Carolina State line on the south complete the boundaries.

Evidences of soil losses are briefly touched upon, as are the factors contributing to these losses. The major part of the discussion deals with measures of defense that are now being employed on farms within project areas of the Soil Conservation Service and on farms in areas where members of C. C. C. camps have been assigned to erosion-control activities.

The many types of agriculture represented in the Northeast—general farming, dairying, orcharding, market gardening, and single cash crops such as potatoes—are more fully discussed in the last chapter, entitled "Outposts of Cooperative Defense," which describes six projects in typical farming areas.

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Soil Defense in the Northeast

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Soil Conservation Service, in Collaboration with Subject-Matter Specialists

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Contents

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FIGURE 1.—Many pleasant valleys in the Northeast do not show severe soil losses from erosion

A Soil Problem in Disguise

CLAD IN A MANTLE of vegetation—grass, shrubs, vines, and trees—the innumerable pleasant landscapes in America's Northeast seem to deny any present or past wastage of soil resources. From railroad windows passengers are heartened to gaze upon a countryside that seems to stay put. Vacationers and tourists see sparkling streams and lakes of clear water. And many farmers dwelling in peaceful valleys (fig. 1) are thankful that they do not live where dust storms are common, or in one of many other regions where gullies are said to be making cancerous chasms in the earth and driving men from the land.

Casual reflection sustains this view. Ordinarily rainstorms are less violent than they are in the interior regions of the continent. And freezing weather and a normally heavy blanket of snow protect the land much longer during the year than in regions farther south. The few gullies, in comparison with other areas, help to justify the complacent feeling of security in the stability of the land.

Damage by erosion, however, will be noticed by the observer if he looks at specific areas in the Northeast. For example, some of these areas are: The tobacco-growing section of Maryland; the trucking and fruit areas of New Jersey; the tobacco-growing Connecticut Valley; the vineyards of New York; the area of Maine intensively growing potatoes; and the dairy section along the Winooski River in northern Vermont. While soil losses in these localized regions are apparent, the greatest damage, in the Northeast as a whole, is caused by the comparatively imperceptible effect of widespread sheet erosion.

Accelerated erosion, the man-made kind, started soon after our ancestors settled along the Atlantic coast. For thousands of years, prior to their coming, nature labored slowly in building the soil. Meanwhile the country was in the custody of Indians, whose desires and activities were admirably suited to the preservation of natural resources. The Indian, it is true, taught the white man the use of agricultural practices which are now viewed as scientific marvels; yet the Indians cultivated only small patches of land near their villages, and these were usually located on comparatively level tracts near tidewater, along a stream, or on the margin of a lake. Berries, fish, and wild game supplemented

the "three sisters" of their vegetable diet—Indian corn, beans, and squash. The Indian could thrive on this diet, but the white man found it difficult to get along without wheat.

Before our ancestors stood a vast forest that lifted in a billowy pattern to the highest summits of hills and mountains. This forest wall was a barrier against the food supply, and the necessity to subdue it is a compulsion understood by all men. In view of the dwindling food stocks and the uncertainty of replenishments arriving by boat, it appeared imperative that the colonists clear the land so that they might raise grain for bread. Some, it is true, notably the French, were trappers and traders; others—the Spanish particularly—were seeking gold; but to all who sought a permanent abode the food supply was the vital problem.

France, in claiming the vast interior region of the continent, temporarily halted the westward surge of English colonists. Thus the clearing and cultivation of land in the early days was confined to a narrow belt east of the Appalachian Mountains, extending from southern Maine to Georgia. Later, when French claims were out of the way, the "floodgates" opened, and settlers poured through the Appalachian Mountain passes, laying the land bare by hacking, burning, and clearing as they went. "Fire, set loose," writes U. P. Hedrick in his History of New York Agriculture, "was the quickest and most efficient means of destroying the forest growth." Frequently trees over a considerable area were girdled. The resulting "'deadenins,' when set fire," he adds, "made bits of frontier hells * * *."

Even in the early days a crude system of "resting" the land was adopted. It was described by an English traveler as the "infield and outfield" method. About a third of the settlers' holdings came under the plow at any one time. While this area was being exhausted and eventually given a "rest," another portion was cleared of trees and cropped. This process was repeated until the area first cleared had partially regained its productive powers, when it was again plowed. This system, the English reporter revealed, was adopted not from a lack of knowledge, but from stress of circumstances.

Looking backward, one may understand to some extent the effects of the "chop, crop, and get-out" methods upon the soils of the agricultural lands from the seaboard westward through the forested area. The forest cover was removed from the hilly and sloping lands making them vulnerable to erosion. Unquestionably fire destroyed a considerable portion of the organic matter which had protected the surface soil under forested conditions. It tended to bake the surface layers of soil and to change the open structure from a granular to a clodded condition. The lack of grass, noted and deplored by English travelers, prevented the use of a systematic crop rotation and the seeding of pastures. Cheap land enabled the pioneer to clear additional areas of his own holdings or to move to new areas when he became dissatisfied with his crop yields. In more northern portions of the region, climate favored the early invasion of bluegrass and wild white clover.

Thus a volunteer pasture cover was given to many hills and slopes. Yet clover and timothy as an artificial meadow-grass seeding seems not to have been used generally until about 1835.

The trails of the principal single crops—wheat, corn, cotton, tobacco—had their beginnings on the eastern seaboard. Wheat and corn marched inland over much of the same area until corn found its permanent home in the Midwest. Wheat continued westward, spreading fanwise over most of the Great Plains. Cotton, with a quicker stride, swept south and west from the Carolinas and Georgia, leaving in its wake thousands of acres of racked soil which today is little more than an infertile waste.

Except in a few isolated instances, the Northeast did not lend itself easily to speculative, exploitative single crops which in the West and South were so inviting. Extravagant expectations were denied by the topography, soil, and climate. These natural conditions enforced thrift and a diversity of farming enterprises.

Farmers in the Northeast had their difficulties, however, when the expansive West opened and the ever-increasing volume of farm products came flooding eastward. At about the time of the Revolution the Hudson River Valley was called the "Bread Basket of the Nation." It competed for attention with the rich limestone section of Pennsylvania that had attained the title "Granary of the Nation." Later these titles shifted westward as canals and railroads opened fresher and fresher lands farther and farther west.

Throughout the Northeast, in more recent years, land abandonment has been written indelibly in the agricultural record of practically every State. Just how much of this abandonment has been caused by overcropping and competition from the West or from other causes, nobody knows. It is clear now, however, after a little more than two centuries of occupation, that erosion, and particularly sheet erosion, has been one of the major factors. Though a wounded soil—later completely abandoned or devoted to pasture—may disguise itself with briars, sedges, devil's-paintbrush, and what not, giving the appearance of slow recovery under a mantle of vegetation, it is probable that the soil is being washed off the surface at a greater speed than it is being restored by natural processes. This inadequate cover of vegetation is incompatible with good soil husbandry and good farming; nevertheless, it helps to create the illusion that the land is being conserved—an illusion heightened by well-forested upper slopes.

Under cultivation, for any considerable length of time, practically no soil in the Northeast grows profitable crops without the application of commercial fertilizers. And, the trend has been toward heavier and heavier applications per acre. These increasingly heavier applications of commercial fertilizers, along with other improved cultural and management practices, have tended to mask the ill effects caused by the loss of surface soil, and the removal of plant food through crops. Yields in many instances have been held even or perhaps increased, but the natural productive capacity of the soil has been impaired.

Lost Soil

ON THE ROLLING HILLS near Flushing, Long Island, in 1903 J. A. Bonsteel was engaged in making a soil survey for the United States Department of Agriculture. Here the early Dutch settlers of Peter Stuyvesant's time had started their boweries or farms. Bonsteel saw two men near a stone fence loading soil into a two-wheeled, one-horse dumpcart. When filled, the cart was drawn up the hill, and the soil was spread upon an almost barren knob.

With a soil auger at hand, Bonsteel bored into the earth on the uphill side of the fence near the spot where the men were digging. His auger went down and down almost 2 feet before going beyond the rich accumulation of topsoil that had been washed there from the hill. Pressed for an explanation, the men said they had a little spare time and that they believed it was cheaper to haul the dirt back than to buy stable manure. Under the prevailing economy of the time, Bonsteel estimated that it would cost $500 an acre to lug even a 6-inch covering of that soil back to the place from which it came.

Bonsteel was one of the soil scientists who was early impressed with the seriousness of soil losses by erosion. Yet only recently has erosion emerged from the realm of discussion to the realm of measurement. In 1917 M. F. Miller and F. L. Duley, of the Missouri Agricultural Experiment Station, installed the first measuring device to record soil and water losses under various crops and conditions. Their method, though now somewhat refined and improved upon, is still standard. Strips of soil, of the same slope, lying side by side up and down the hill, are surrounded with treated wood or metal to prevent the entrance of run-off water or soil from the outside (fig. 2). At the foot of each strip devices are provided to measure the soil and water loss. These strips are planted to crops and rotations of crops that prevail in the region. Experiments such as these are now being carried forward and extended by 15 soil conservation experiment stations, three of which are in the Northeast (see back cover page), and by many State colleges and experiment stations. Findings at these stations provide the basis for our recent and more exact knowledge of soil removal.

FIGURE 2.—Equipment such as this provides measurements to determine the extent of soil and water losses.

By and large, under natural conditions topsoil is removed no faster than it is replaced in the slow building processes from beneath. Under these natural conditions there is some erosion, but this is not serious.

But if you remove nature's cover of thick grass, trees, vines, and shrubs, and if you pulverize the soil year after year as in continuous row-crop farming, you derange the natural balance of soil formation. Soil is then taken from the top much faster than it is being rebuilt below. Present-day high-powered machinery, though it may help temporarily to unlock plant nutrients, hastens the process with an acceleration that is thoroughly modern.

Sheet erosion, the most imperceptible type, yet by far the most damaging, removes thin films of soil, layer by layer, from unprotected land. The surface, under sheet erosion, is usually smooth looking, and the lost soil well-masked. Furthermore, sheet erosion is a selective process; it takes the most productive part of the surface soil first, leaving the less productive on the field.

Gully erosion may have its inception at any time, but it usually follows after about one-half to two-thirds of the topsoil has been lost through sheet erosion. Moving down unprotected slopes, silt-laden water, accumulating from converging smaller slopes, forms slashing streams that etch out gullies (fig. 3). These gullies may in time eat into the earth until they strike bedrock. And they may march up the slope to the crest of the hill, making it impossible to cultivate the field. Yet in the impoverishment of most fields, gullies play a small and incidental part. They are the belated evidence of an advanced stage of sheet erosion.

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FIGURE 3.—Gully erosion usually follows after about one-half to two-thirds of the topsoil has been lost through sheet erosion.

Soil scientists in 1934 examined the surface soil in a general survey of innumerable areas throughout the country to determine the extent of erosional damage. The results of this survey, in the main, have focused the attention of the Nation upon the amount of topsoil lost by erosion. Here in the Northeast, when all figures were assembled and analyzed, the loss of surface soil ran beyond all expectations; yet the loss in tons in no way compares with the more intensively cultivated regions of the Middle West and South. Briefly, the results in the Northeast show that more than one-third of the region has been damaged by sheet erosion—the damage varying from slight topsoil losses in some places to the loss of all the topsoil and considerable subsoil in other sections. Gully erosion, varying all the way from slight to very severe, has affected probably 20 percent of the region.

While the loss of surface soil, as expressed in inches or tons, may be small in comparison with other areas, yet the actual damage may be more severe. The original surface soil over most of the area probably had much less depth than that of the Middle West. In vast areas of the Middle West the original surface soil or topsoil, measured from 16 to 20 inches or more in depth. Thus a 4-inch loss of surface soil in the Northeast probably causes more land impoverishment or abandonment than would an 8-inch loss in the richer soils of the Middle West.

To many farmers erosion is not a problem until gullies have made it impossible to cultivate fields in a normal way. So long as miniature gullies can be crossed with farm tools and thus become obliterated, the soil loss is frequently not appreciated. Though gullies have been rubbed out, washing will continue, and if rains are severe more gullies will form. The gullies are bothersome and make

farming operations more difficult, but they signify a condition that is far worse than the inconvenience they cause.

Soil material carried to the ocean consists of colloidal matter, clay, silt, and the finest grades of sand. From this material crops can extract plant nutrients more easily than from the coarser soil particles.

Not all of the washed soil material goes as far as the ocean. Much of it is deposited in reservoirs, lakes, swamps, flood plains of streams, and the base or flatter parts of slopes. This loss of soil, scientists now believe, is many times greater than the total lost in the sea.

Run-off water carries soil particles which embody plant nutrients. In addition this run-off water carries immense quantities of fertility elements that are in solution. These dissolved nutrients may have been purchased in a relatively expensive form as commercial fertilizers. They may be replaced at a considerable expense, but this loss in no way compares with the loss of the body of the soil itself. Furthermore, this soil can never be returned to the fields whence it came at an expense that can be justified. It is gone.

Existing water-power plants, either those in use or those abandoned, indicate much that has happened on the watershed which feeds them. In such a well-forested region as the Adirondack Mountains many of these old water-power plants continue to operate (fig. 4). The stream flow is clear and fairly uniform due to the forest cover.

FIGURE 4.—Many water-power plants continue to operate in the Adirondacks. The stream flow is usually clear and fairly uniform due to the forest cover.

As a contrast, consider the farming community adjacent to Ithaca, N. Y., at the foot of Cayuga Lake. Eleven dams have been built on various streams in the past. Seven of the eleven ponds are now completely filled with silt. Three of the remaining four are located on one creek and are only partially functioning. The fourth, still in service, is the Ithaca city water reservoir. Built in 1910, this dam had an original capacity of 357 million gallons of water. Twenty-five years later (1935) engineers figured that the capacity had been reduced to 276 million gallons, a decrease of about 23 percent. Rough, but conservative, calculations indicate that during the 25 years the reservoir received an average of 83 tons of soil from each cleared acre of land in the drainage area.

Farther south (in northern Maryland) many formerly thriving river ports are closed to all but the smallest of crafts. Joppa, on the Bush, was once the tobacco metropolis of Harford County when tobacco was the prevailing crop. Today silt prevents boats of cargo size from docking at the port. As late as 10 years ago fair-sized steamers made frequent trips up the Susquehanna, docking at Port Deposit. Though some skippers will occasionally make the trip now, the shifting shoals of silt discourage most of them.

Among their endeavors to gain unrestricted control of the Chesapeake (War of 1812) British seamen pursued an American gunboat flotilla up the Patuxent River in August 1814. This river roughly parallels the Potomac and is about 18 miles east of Washington in its more northern extremity. Rather than submit to capture, the Americans sank their boats in the river near Nottingham. Folks now living tell about the souvenirs which plucky divers later recovered from these shallowy submerged crafts. But today, silt prevents all but the smallest boats from entering these waters. Up the river, at Upper Marlboro, tobacco scows once docked immediately back of the Episcopal Church. The church still stands, but silt from the countryside has filled the harbor. It is a swamp today.

The purpose of this bulletin is not to dwell at length on the loss of soil through erosion. Rather an attempt is made to outline the best known procedures for stopping the loss of the remaining topsoil and to explain the measures that are now being taken by the Soil Conservation Service in cooperation with the man on the land. Topsoil could be preserved in the Northeast, as elsewhere, if all of the land susceptible to erosion were restored to nature's protective mantle of vegetation. Yet men must get their food from the land, and the obvious and sensible policy is to safeguard all areas with the best known and most appropriate devices to hold soil while deriving a living from it.

Climate, Slopes, Soil, and Crops

THE PRINCIPAL FACTORS affecting soil erosion are: (1) Distribution and intensity of rainfall; (2) the topography of the land, which includes the degree of slope, and the total slope area drained by the individual drainageways; (3) the erodibility of the particular soil type; and (4) the type of soil management practiced, with special reference to the vegetative cover.

Climate

At Culebra, Isthmus of Panama, our Government found that vegetables could not be raised successfully without irrigation despite an annual rainfall that averages 86.64 inches. The profuse rains (more than twice as much as received by farmers in the Northeast) come at the wrong time of year for the benefit of plants.

Soil erosion, as well as crop production, is closely linked with rainfall; however, it is the distribution throughout the year and the intensity of individual rains rather than the total amount that must be reckoned with. We Americans jest about the English who are said to go through life with an umbrella or raincoat at hand. Yet for the last 35 years the rainfall at Camden Square, London, has averaged but 24.47 inches, as compared with the 30 to 50 inches in our Northeastern States. Frequent gentle showers rather than infrequent pelting rains characterize the weather in the British Isles.

During several months of the year the northern areas of the region are usually well protected by a blanket of snow. Snow protects the vegetative cover of grasses, legumes, and winter grains by preventing frequent freezing and thawing of surface soil. This cover makes it less susceptible to wash from late winter rains. However, later, when spring rains and higher temperatures come, usually in March and April, the snow melts, and it is during this period, when water from melting snow is added to the normal monthly rains, that the most startling losses of soil occur. Snow and rain during March, April, and May make up 20 percent of the total annual precipitation for the region at all of the lower altitudes and increase to 25 percent or more at all of the higher elevations.

This is the period when destructive floods usually visit the estuaries above tidewater and deposit rock, sand, and silt from eroded fields and stream banks. It is in this period, likewise, that startling damage is visited upon villages and cities adjacent to streams and rivers.

June and July is another period when land suffers from heavy rains. During these months spring- or fall-sown grain and intertilled crops are inadequate to hold the soil. Either the surface of the ground is bare because of preparation for tilled crops like corn, potatoes, or tobacco, or it is inadequately protected by the rough growth of winter wheat, spring wheat, oats, and barley.

On June 19, 1936, rain gages at the Soil Conservation Experiment Station, Arnot, N. Y., recorded 1.46 inches of rain, 1 inch of which fell in 10 minutes. On a plot of cornland (72 feet long and on a 20-percent slope) 7,586 pounds of soil were lost, along with 45 percent of the water, in this brief period. During the next 6 weeks only 1.7 inches of rain fell and crops suffered. A single rain is frequently responsible for a large percentage of the soil and water losses of the season.

Slopes

A boy on his sled knows that he can travel faster down a steep slope than on one that is less steep. He also knows that he may start slowly but will pick up speed down a long gentle slope.

Water, likewise, runs faster down a steep slope than it does on one less steep, other factors being equal, and fast-moving water is very erosive. Long slopes, even if gentle, permit water to gain speed, and this increased speed, along with the increased volume, accelerates the eroding power (fig. 5).

To conduct water safely down a long, steep slope over a drop of several hundred feet in elevation is always a difficult job. Stabilized outlets may be difficult to find. Moreover an outlet that is stable for a normal quantity of water may become unstable if an increased concentration of water is thrown into it. New gullies may appear, creating a more difficult problem than the original.

Soil

When we think of soil as related to erosion, at least two soil properties must be kept in mind. One is the rate of absorption, and the other is the water-holding capacity.

Coarse-textured soils, such as sand and sandy loams, resist erosion because they permit rain water to enter more readily and thus reduce or eliminate run-off from normal rainfall. These coarse-textured soils, however, frequently contain insufficient fine material to bind particles together and so permit erosion. Again, coarse soils may hold such small amounts of water during a drought that plants suffer and the vegetative cover is impaired.

Fine-textured soils, at the other extreme, clays and clay loams for example, permit rain water to penetrate more slowly. A greater percentage of water falling on these soils may be lost even on a moderate slope. If water is once taken up by these soils, however, it is held available for growing plants, and droughty periods will have less effect than on the coarse-textured soils.

Pattering raindrops on many fine-textured soils developed from lake-laid deposits dislodge particles with ease. Once in suspension, these small particles may be carried by even slowly moving water. For example, the Dunkirk soil, found along the comparatively level Ontario Lake plain, has been observed to erode on land sloping less than 3 feet for each 100. Under cultivation this soil requires astute management to prevent severe soil losses.

FIGURE 5.—Long slopes, even if gentle, permit water to gain speed and volume thus accelerating the eroding power.

Organic matter is destroyed or depleted when intertilled crops, such as potatoes, corn, and various truck crops are grown on the same land year after year. By increasing the organic matter in these soils the tilth and physical condition are improved. The organic matter serves as a sponge to absorb water, and it tends to give soils the desirable granular condition. In a well-granulated soil the particles cling together and act as a unit physically. This improved physical condition permits water to enter these soils more readily and to be held available for plants. Consequently water that is absorbed and held by the soil cannot be lost by percolation or by run-off.

The absorptive capacity of a soil is not entirely determined by the topsoil. A loose, porous, and deep surface soil is highly desirable, but a man who owns a farm on which the subsoil is open and permeable usually has a decided advantage over the man on whose farm the subsoils are tight and impervious. When the latter type of soil has absorbed all of the water which it will take, and this is limited, any additional water must run off the surface. Occasionally, however,

one may find a surface soil that leaches so readily that an impervious subsoil may check the downward passage of plant nutrients and thus prove beneficial.

Crops

If we place the names of all crops in a list and arrange them by groups in order of their ability to protect soil we shall find a wide difference. Grass, shrubs, trees, and permanent hay including alfalfa and clover, will top the list. At the bottom we find the worst offenders, the row crops such as potatoes, corn, tobacco, and truck crops. Between these extremes we find an intermediate group, the small grains such as oats, wheat, rye, barley, and the various annual legumes.

FIGURE 6.—Thick grass protects the soil against the lash of rain and the rush of water.

It is obvious upon examination why certain crops vary in their ability to protect soil. Grass, with its innumerable blades above ground, prevents rain from striking the soil (fig. 6). Underground the maze of entangling roots holds the plant and soil in place. These decaying roots leave passages for air and water, and the increased supply of organic matter increases the absorptive capacity of the soil. Trees, with their overhead canopy of leaves and branches, check the pelting force of raindrops (fig. 7). The thick mulch of decomposing leaves and twigs on the surface soil and decaying roots below, permits water to enter readily, thus reducing the run-off. Corn, potatoes, tobacco, and truck crops are usually planted in rows widely spaced. The intervening soil is stirred and pulverized to kill weeds. This produces a finely pulverized soil, often a dust mulch, which is easily whisked away by rushing water. The so-called close-growing crops such as wheat, oats, rye, barley, and the various legumes are never intercultivated; but caution must be exercised even with these if the land is steep or if it does not absorb water readily. Under these conditions the drill rows should run on the contour, and the long slopes should be broken with strip crops, diversion terraces, or terraces.

On the low rolling foothills of the unglaciated Appalachian region near Zanesville, Ohio, tests have been made comparing the erosion-resisting qualities of crops on the Muskingum silt loam. On this land, sloping 12 percent, plots were laid off to compare the water and soil loss when corn is grown continuously; corn, wheat, and grass in rotation; and grass alone. Over a 2-year period (1934–35), and under a rainfall averaging 34.5 inches annually, 35.2 percent of the precipitation was lost when the land was planted continuously to corn. Nearby, on plots handled under a rotation of corn, wheat, and grass, the water loss amounted to only 18.4 percent of the total rainfall and snowfall. The bluegrass plot, also nearby, lost only 4.5 percent of the precipitation.

The corresponding annual soil losses were: From land devoted continuously to corn, 59.6 tons per acre; from land in rotation, 8 tons per acre; and from land covered with bluegrass, a mere 100 pounds per acre.

At these rates, it would require only 19 years to remove 7 inches of topsoil from land planted continuously to corn, 145 years to wash off an equal depth of soil under the crop rotation, and 23,200 years to carry away as much topsoil from the field in bluegrass.

FIGURE 7.—Trees provide excellent protection against erosion.

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Defense Measures

FARMERS CAN DO NOTHING TO CONTROL or alter the climate, nothing to change the natural topography of their land, nothing to change the basic materials from which their soil was derived. Most farmers can, however, crop their land more skillfully, do something to make their soils more permeable to rainfall, and thus reduce the amount of water which now journeys to the rivers and the ocean, carrying away soil. Improving the porosity of the soil and so trapping more moisture, may have as its immediate goal a greater financial return from an increased crop. The motive matters not so far as erosion is concerned, because soil is saved whenever less water is permitted to flow over the surface.

In humid regions like the Northeast it is impossible, at all times, for the soil to absorb all of the water that falls on the land. Water that is not absorbed by the soil must be disposed of, and the degree in which it is marshaled safely off the land largely determines the extent of erosion control. All methods of conducting this surplus water safely off the land are based upon the simple principle of checking the rate of flow. Slowly moving water drops its load of silt, and the cutting power is reduced. These principles are involved in all control measures, both new and old.

Farm Management

Most farmers can look over their land and recall past mistakes of their own or of previous owners. Here is a field, for example, that should have been left in timber; there is a slope that should have been left in pasture or meadow; row crops did well on still another field until the organic matter and fertility were depleted.

To a degree, influences outside or off the farm such as transportation facilities, distance to market, real estate values, consumer whims and desires, to name a few, may govern the particular crops grown on the farm. The desire to supply products for a temporarily favorable market may push the plow onto grassy slopes that should never have been opened to the wash of rains. Or the necessity for meeting current financial obligations may make it seem necessary for the

owner to follow a punishing type of soil husbandry against his own best judgment. These problems are not easily solved, and it takes a high type of farm management to preserve soil resources and at the same time resist the urge for greater immediate gain rather than the benefit of more modest returns over a period of years. It is a choice of making changes deliberately to preserve soil resources or having more unwelcome changes thrust upon one after the soil is gone.

The most important initial step in the control of erosion is placing each parcel of land in the crop or rotation of crops to which it is best adapted. If the steeper slopes cannot be kept in a productive pasture through improvement practices, they should be planted to trees. If land now under cultivation and given the advantage of soil conservation practices cannot be farmed on a sustaining basis it should be converted to pasture or meadowland.

The erosion-control practices discussed in the following pages are not offered as one-two-three measures for farmers to apply. Rather each of the present known methods is briefly discussed so that farmers may select intelligently the combination of practices best adapted to their own requirements.

Contour Farming

Our inherited rectangular system of farm lay-out of land has enforced field arrangements that are inappropriate for a rolling countryside. It has been said that this system "tried to fit square farming to a round country." As a consequence many farms lie in a long narrow strip leading from a valley up the grade to a plateau at the crest of the hill. To aggravate this situation these farms have frequently been subdivided lengthwise into several fields. Farming these long fields up and down the slope has been a direct cause of severe soil loss.

There are a number of obvious reasons why fields should have been laid out on the contour or across the slope. Plow furrows around the slope make a series of soil dams that hold water on the field, giving it more time to soak in rather than run off; harrow teeth leave smaller but more of these obstructions, and cultivator teeth leave similar grooves on the soil devoted to row crops during the growing season. Since grass seedings or mixtures of grass seedings are usually made as the grain is being drilled, or soon after, much of this seed falls into or is washed into the drill furrows. Consequently, both the plants of the nurse crop and the grass plants emerge in contour lines. The resulting rows of grass on the contour more effectively check the flow of water than they would if they ran up and down the slope.

Farmers who have tried contour farming report that field work is much easier on man and team because all machinery is drawn on the level (fig. 8). Present evidence indicates that much less power is required to farm on the contour than going up and down the slope.

Figure 8.—This Pennsylvania field is being farmed on the contour or around the slope on the level. Farming around the slope, instead of up and down, makes easier work for man and team.

Strip Cropping

Strip cropping is a proven device for holding soil. Though it has been employed by farmers in a few scattered communities in the Northeast for many years, the recent widespread interest in this practice came as a result of the numerous cooperative field demonstrations conducted by farmers with the Soil Conservation Service. A few farmers in northwestern West Virginia, southwestern Pennsylvania, and southeastern Ohio have strip-cropped their fields for over 25 years. An Ohio farmer who has strip-cropped his farm since 1908, says: "We would not think of going back to the old way of plowing a whole field."

To strip-crop a field, one plants the crops in long and relatively narrow bands of approximately equal width across the slope on the contour. Clean-tilled crops such as corn, potatoes, and tobacco (all erosion-permitting) are alternated with grass, small grains, and legumes (all erosion-resisting) (fig. 9). Unless exceptional conditions are encountered, there should be little deviation from the true contour. Safe deviations from the true contour are based upon the particular type of soil; these conditions should be known before any attempt is made toward laying out a farm for strip cropping.

Soil-laden water flowing down from the clean-tilled strips encounters the bands of thick vegetation in the next strip below. Since the rate of flow is checked by the stems of plants, soil is deposited. And, since the water has been made almost clear by this filterlike action, it enters the soil more readily because there are fewer soil particles to seal the downward passages. If row-crop strips are

given this protection from the wash above, and if there is another strip below ready to catch soil and water, little damage need be expected from any except the heaviest of rains.

Whether strip widths should be narrow or broad will depend on the degree and length of slope, absorptive and water-holding capacity of the soil, rainfall, and other factors. On the Soil Conservation Service project areas and in areas where members of C. C. C. camps have been assigned to aid in erosion control, strip widths are being studied under a wide range of conditions, and also at erosion experiment stations. In general, present information indicates that strip widths may vary from 50 to 125 feet. Some soils on steep slopes may wash even if the cultivated strips are less than 50 feet, while other soils may not erode severely if the cultivated strips are 125 feet in width. Strip cropping is a flexible practice; hence, if the original strips are found to be too narrow or too wide they may be corrected easily.

In practice it is desirable, where possible, to make the cultivated strips of uniform width to eliminate point rows. It is also desirable for a farmer to consider width of strips in relation to his implements. If a farmer grows potatoes on a commercial scale he should lay out the strips of such a width that he will make the most economical use of the various tools used throughout the season. He will wish to figure closely how many round trips would be necessary with his sprayer or duster. He would not want the strips of such width that it would be necessary to dust or spray one row. If he has a two-row digger he would not want an uneven number of rows in the strip.

In areas where corn is regularly grown in the rotation many farmers prefer having the width of cultivated strips determined by the number of shock rows of corn. For example if the slope is steep the strip may be just one shock row wide. When strips are but one shock row in width most farmers prefer to shock their corn on the edge of the adjacent meadow strip (fig. 10). This practice per-

Figure 9.—Strip crops as applied to a New York field.

mits the solid drilling of wheat on the strip from which the corn was removed and husking is a more pleasant task later in the fall. This practice may be used if there are two shock rows of corn in the strip, but of course it means that half of the corn stover must be carried a greater distance to the edge of the meadow strip. If a portion of the corn crop is to be made into silage, it is possible to harvest this corn from the middle of the corn strips and thus reduce the distance that the remainder of the corn need be carried. This, however, necessitates

FIGURE 10.—Corn shocks have been placed on the adjacent meadow strip. In this way wheat may be seeded in the entire strip from which corn was removed

cutting one row of corn by hand, through the middle, to permit the use of machinery.

Let us assume that a farmer has a sloping field and that he wishes to strip-crop this field, using a rotation of corn, small grain, and hay. Figure 11 shows how this may be accomplished and any serious derangement of the cropping sequence avoided. If a rotation of potatoes, wheat, and hay is preferred, the adaptation can be just as easily made. Likewise the longer rotations, which include a greater variety of crops, may be used. The important point to remember is that strips in row crops should be protected from above by strips of thick-growing crops.

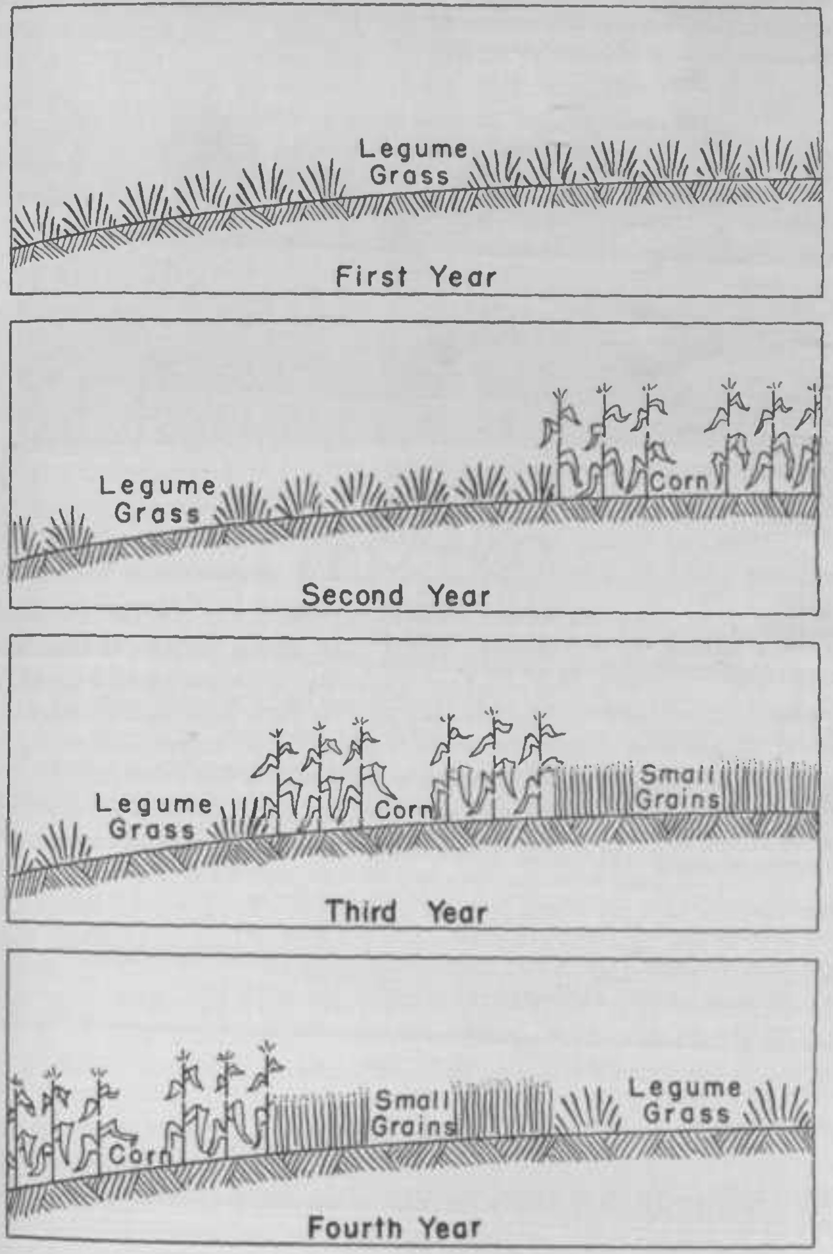

FIGURE 11.—Showing how strip cropping may be started in a field.

FIGURE 12.—Sweetclover was seeded in this Lancaster County, Pa., field during the last cultivation of corn. A good winter cover is assured.

Cover Crops

Winter cover crops can serve a twofold purpose in the control of erosion. (1) They protect the soil against dashing rains during the fall, winter, and spring, when no regular crop occupies the land. (2) When plowed under, if they have attained sufficient growth, they increase the organic-matter content of the soil, thus making it more absorptive of water. Rye, wheat, and several of the legumes may be seeded for a cover crop following the last cultivation of corn (fig. 12). If seeding is delayed until after the corn is harvested, in the northern area, the cover crop attains insufficient growth to give adequate protection.

In the more northern areas it is likewise a difficult problem to find a satisfactory cover crop for land on which potatoes are grown. The potatoes are usually harvested so late that the cover crop has insufficient time to establish itself adequately to constitute a protection against erosion.

In the southern areas winter grains are common crops in the rotation, and they normally attain sufficient fall growth to give some protection to land during the winter and spring months, making the use of cover crops, as such, unnecessary.

Grassed Waterways

Most cultivated fields in the Northeast have depressions or draws which serve as paths for surplus water. If these paths are kept permanently in grass they provide an excellent means of conducting water safely off the field. Everywhere one may find a few farmers who have a commendable and instinctive reluctance to plowing through these paths. Far more frequently one finds farmers who

will not take the time to lift plows or cultivators, or straighten disks when crossing these watercourses. A terrace system, if properly built, always provides facilities in the form of terrace outlets for the safe disposal of surplus water after it has left the terrace channels. It is fully as important to provide and protect similar facilities on fields that are being strip-cropped or contour-farmed. Grassed waterways in strip-cropped fields serve the same purpose as terrace outlets on terraced fields.

There are two types of grassed waterways. One type, used in connection with strip cropping or contour farming, is comparatively broad, and the area included in the waterway is kept permanently in meadow. The other type is more often used in connection with diversion ditches or terraces particularly where natural depressions do not occur. It is comparatively narrow, and the waterway is given a thick, low-growing, turf-forming type of vegetation that will fold down under the pressure of water, like shingles on a roof.

The grassed waterway used in connection with strip cropping or contour farming is seeded with the same grasses or mixtures of grasses that are seeded on the meadow strips (fig. 13). Hay is harvested from the waterway and the strips at the same time. The seedings include the grasses and legumes that are adapted to the region. Bromegrass and orchard grass are among the newer species now under trial in many of the project areas.

A common mistake in laying out waterways in a strip-cropped field is to make the area too narrow. An adequate width for erosion control will depend upon the size of the drainage area, the tilt of the land, the width of the strips, the type of soil, and the rotation followed. All of these factors must be considered; yet many farmers are finding that it is easier to maintain the grass areas if they are much wider than is absolutely necessary for erosion control. And furthermore they are finding that these areas may frequently produce the highest hay yields on the farm or good pasture if they can be made accessible to stock.

The grassed waterway used in connection with terrace outlets or diversion terrace outlets is seeded with various combinations of grasses and legumes. These combinations usually include bluegrass, bentgrass, Ladino, white clover, and in southern areas, lespedeza. A mixture of grasses usually gives the best results. If seasonal conditions are unfavorable for one species another may make sufficient growth to give some protection. These low-growing grasses and legumes should not be cut for hay although they may be pastured by tethering animals upon them. Care must be exercised, however, to see that the turf is not damaged by trampling.

To establish a dense cover it is frequently necessary to increase the organic matter and fertility of the soil by an application of manure and phosphate. Mulch is frequently used at the rate of 1 or 2 tons per acre. The mulch is held in place with chicken wire until the new seeding becomes established; after that the wire is removed and may be used in another location.

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FIGURE 13.—This waterway is kept permanently in grass. Hay is harvested from the waterway at the same time that it is removed from the meadow strips that alternate with the corn strips.

Terracing

Considered as a single method of soil-saving strategy, terracing probably has been the most widely tested. Various types have been in use for hundreds of years in the Orient, Central America, parts of Europe, and many other countries. In our own country, after the one-crop cotton system marched across the Southern States, leaving the land open and "bleeding," farmers there, in desperation, developed our first earth embankments to hold soil. Handicapped by inexperience and the lack of appropriate tools and adequate power for use in their construction, many of these early builders constructed terraces that failed to hold the soil. Yet withal, we can thank these southern farmers for developing the highly effective broad-base type of terrace, which serves so well in the South and are now being used also in the North and West.

Despite the most recent improvements, terraces must be supplemented by soil improvement and other control measures. With the exception of permanent grass and tree covers, no single control measure, terracing included, is adequate to hold soil. Terracing, experience has proved, should be combined with crop rotations, strip cropping, and other measures that are most appropriate for a given field. The success of one control method must rely upon the success of the others employed. Frequently good farm-management practices and a good cropping system will fail without the support given by mechanical measures. Likewise a mechanical measure, like terracing, is almost sure to fail without the support of contour farming, an appropriate cropping system, and soil treatment.

Terraces alone cannot be expected to hold soil against the punishing abuse of row crops under continuous cultivation.

On land adapted to their use in the Northeast and on watersheds within project areas of the Soil Conservation Service modern broad-base terraces are now under trial in widely scattered areas. They can now be found in the intensive potato-producing section of Aroostook County, Maine, in the rich general-farming sections of Pennsylvania and Maryland, and in the more level coastal plains of southern New Jersey (fig. 14).

Terraces as applied to farm land for erosion control are surface-drainage channels at appropriate intervals across the slope. The upper side of the embankment forms a channel that intercepts the flow of water as it moves down the slope. Terraces are given a slight fall, which permits the accumulated surplus water to move slowly, and therefore safely, off the field to the terrace outlet. The terrace system, in effect, breaks the original long slope of a field into a series of short slopes, and short slopes permit less erosion than do longer ones.

Generally it is unwise to rely upon terraces for protection of fields devoted to cultivated crops, where the slopes are more than 12 percent (a 12-foot drop for each 100 feet in distance). So much depends upon the absorptive capacity of the soil, farming methods, and the crops grown that rule-of-thumb figures are useless. If slopes steeper than 12 percent are terraced, it frequently requires considerable effort and expense to maintain the ridges at the proper height and to keep the channels clear. When excessively steep slopes are terraced there may be some erosion between the terraces even if the best of cropping and cultural practices are followed.

FIGURE 14.—Planting potatoes on a terraced field in New Jersey. Note that the rows are parallel to the terrace.

Grades and Spacing

In general, terraces in the Northeast are given a slight grade, and this grade is usually variable. The grade should seldom exceed 5 inches in each 100 feet. Starting with a zero grade at the upper end, the grade is generally increased one-tenth inch per 100 feet, at 300- to 400-foot intervals throughout the length of the terrace toward the outlet. Terraces without grade are occasionally used in permanent hayfields, pastures, and orchards.

The slope of a field is the principal factor governing the spacing of terraces; yet the soil type, extent of erosion, and the rainfall must all be considered. The spacings indicated in table 1, based on the original investigations of C. E. Ramser and more recent results obtained at conservation experiment stations, may be used as a general guide in determining the spacing on different slopes.

TABLE 1.—*Terrace spacings on land of different slopes*

Item	Terrace spacing on slopes per 100 feet of—				
	2 feet	4 feet	6 feet	8 feet	10 feet
	Feet	*Feet*	*Feet*	*Feet*	*Feet*
Vertical fall between terraces	2¾	3½	4	4¾	5½
Distance between terraces	137	88	67	59	55

The Outlets

In building terraces in the early days, many farmers gave scant attention to the disposal of water after it left the terrace channel. Water has been discharged upon steep slopes, into small narrow ditches, along roadsides, and onto areas inadequately protected by sod. This oversight has frequently led to the ruin of more land than the terraces have saved. No terrace system is complete until satisfactory means have been provided to ease excess water safely to the natural drainage channels (fig. 15). Even though outlets have been properly designed and constructed they must be given attention year after year. Small repairs must be made promptly; otherwise more costly and larger reparations will be required later.

From many standpoints it is desirable to construct outlets and get vegetation started at least a year before the terraces are actually built on the field. This permits sod to become firmly established and reduces the likelihood of early damage by washing. If this is not done, it may be necessary to divert the water temporarily, thus giving vegetation a better opportunity to take hold. These vegetated outlets should have flat bottoms from 8 to 20 feet wide, depending on the drainage area and slope. The wide bottoms spread the water and thus reduce the speed and the cutting action. The detailed design and the proper location of terrace outlets are important problems; for this reason competent engineering advice should be obtained before construction work is started.

Occasionally the topography of a particular field or the absence of convenient outlets outside the field itself may make it necessary to prepare outlets on the field. These outlets should be prepared in advance of terrace construction.

Mechanical structures of masonry or concrete are sometimes necessary if adequate vegetative protection cannot be obtained. If these structures are required, the grade between structures from notch to apron must be level. Provision must be made for adequate openings for water flow, ample cut-offs, and head walls to avert overtopping, cutting around ends, or undermining. Other details of construction are of prime importance. Since poor planning, a

FIGURE 15.—This terrace outlet provides for the disposal of water falling on the field shown on pp. 36–37.

defective design, or an effort to effect a slight economy by using inferior materials may lead to failure, it is of the utmost importance that competent engineering advice be sought. The cost of materials is slight in comparison with labor costs.

The initial expenditure for a properly constructed terrace system can be quickly lost if improper tillage practices are followed and needed repairs are not promptly made. Small breaks in the terrace ridge after each heavy rain may be quickly repaired with a shovel or a slip scraper drawn by a team. These minor repairs are especially important during the first year when the ridges are settling. Small gullies starting in the outlet may be effectively and quickly checked by sodding. Breaks or leaks around the permanent structures should be filled and tamped; otherwise the damage will become more serious with each heavy rain.

In some areas of the Northeast, because of the steepness of slopes and the relatively shallow depth of soil, terracing as practiced in other parts of the coun-

try may never find such widespread adoption. There are, however, many areas within this region where the soil, slope, climate, and the intensive type of agriculture followed abundantly justify the protecting arms and additional support that terraces might give. These areas frequently have a high valuation per acre, and on them the cost of producing agricultural products is high. Although terracing requires a cash outlay, no farmer who has land adapted to terracing should hesitate to incur the expense if terraces will help protect his original investment in the soil and his annual investment in fertilizing materials.

Diversion Terraces

A somewhat modified form of a terrace system, called the diversion terrace or diversion ditch, is receiving praise from many farmers who have land that is not well-adapted for a complete terracing system. This is true particularly in the dairy and general-farming areas of New York, Pennsylvania, Maryland, eastern Ohio, and West Virginia. As a general rule, grass in these areas remains longer in the rotation than it does, for example, in the more intensive cash-crop areas of Aroostook County, Maine, the trucking areas of New Jersey, or the tobacco section of southern Maryland. However, on some of the longer slopes where water converges in greater quantities, and where the cropping area lies below a large drainage area, the diversion terrace offers a helping hand to the vegetative control.

On areas of this type where the cropland is usually found in valley floors and edges onto the steeper slopes, followed in turn by pasture and the woodland still higher up, covering the top of the hill, the diversion terrace is found to be especially useful. Just below the pasture field, soil conservationists place a diversion terrace to prevent water from running down over the cultivated area. The cultivated land below the diversion terrace will be strip-cropped on the contour. If the slope in the cultivated area is long, additional diversion terraces will be placed between the cultivated strips.

When diversion terraces are constructed on cultivated land in connection with strip cropping the area immediately above the terrace must be placed in permanent sod. This grass cover catches and holds any silt that might be washed from a cultivated strip into terrace channels. Unless this is done the silt is liable to form dams in the channel and cause the ultimate failure of the ditch. At the present time agronomists and engineers feel that this grass cover should be not less than 40 feet wide and wider if possible. Effort should be made to increase the fertility of this strip, thus making the cover more effective.

Diversion terraces or diversion ditches are similar to terraces (fig. 16). They are usually given more capacity than a standard terrace because they handle greater quantities of water. They may be narrower at the base and higher at the crown than the standard terrace, but they must be broad enough and low

FIGURE 16.—A diversion terrace in a West Virginia field. Note the grass strip above the channel.

enough so that grass can be mowed easily. Like the standard terrace, the diversion terrace is never used unless a suitable natural outlet can be found or one can be built at a reasonable cost. Diversion terraces have been used on slopes of up to 30 percent, whereas the standard terrace is seldom used on slopes of above 12 percent.

Pastures

Pasture is a crop. Yet, the pasture on most farms receives only "stepchild" consideration in comparison with other crops. Productive pastures (fig. 17) protect the soil on a farm in two ways: (1) The thick sward is ideal protection against erosion; and (2) the increased income made possible by the higher carrying capacity makes it less necessary to provide additional supplemental feed from cultivated land.

In recent years exhaustive studies relating to the pasture problem have been made by both Federal and State experiment stations. Better practices worked out as a result of these studies have been demonstrated, and the information gained has been made available to farmers through the various State colleges and extension services. As a consequence, one can find numerous examples in the Northeast where a pasture infested with poverty grass and devil's paintbrush and carrying one cow on 3 or 4 acres has been made to profitably carry as much as one cow to the acre.

In general, pastures usually become unproductive because of depleted fertility or lack of available moisture during droughty periods or because they have been improperly grazed.

Except on certain soil types, which are comparatively rare, potash is usually present in sufficient quantities to promote the growth of desirable grasses and legumes. On the other hand, there is practically never sufficient nitrogen and phosphorus in available form to permit the best growth of pasture plants. Since nitrogen can best be supplied through legumes, like wild white clover, this element is provided when other deficiencies are remedied. An application of lime may be necessary to get the clover started. Phosphorus and lime are the master keys to the solution of the fertility problem on the vast majority of pastures in the Northeast.

Many of these pastures were formerly areas under cultivation which became unprofitable because of depleted fertility. Under grain farming the drain on the phosphorus supply is especially heavy.

On pastures that have never been under cultivation the deficiency of phosphorus may not be serious; yet even pastures that have not been plowed for many years may show a deficiency of phosphorus, owing to its removal through animal and milk products sold from the farm.

To correct the phosphorus deficiency, college and experiment station workers generally recommend an initial application of 300 to 600 pounds of 20-percent superphosphate per acre. This initial application is usually followed every 3 or 4 years with a top dressing of 300 to 400 pounds of superphosphate. These applications, if accompanied with proper grazing management, maintain the pasture on a productive basis. After the initial lime requirement is met, additional ap-

FIGURE 17.—Good pasture is both a crop and a soil conserver. Erosion control alone frequently justifies the cost of pasture improvement.

plications are necessary every 6 to 10 years in order to maintain the lime requirement. In most cases and on average pastures when lime and fertility requirements are satisfied, reseeding is unnecessary.

Some of the changes to be expected in a treated pasture are: Increased growth of white clover, spreading in all directions; the crowding out of devil's-paintbrush, poverty grass, and other undesirable species; the appearances of valuable grasses such as Kentucky and Canada bluegrass, bentgrass, and perhaps others; increased absorption of water by the soil, and resulting denser cover that provides protection against run-off water.

Pasture Furrows

More than a hundred years ago Thomas Jefferson, splashing in leather boots as he walked over his beloved Monticello after heavy rains, observed that contour furrows conserved water and that this additional water could be retained for the benefit of plants. The contour-furrow method has been used widely in the Southeastern States on cultivated land, but more recently it has been successfully applied on sloping pasture fields.

On practically all projects of the Soil Conservation Service and in areas where members of C. C. C. camps have been assigned to erosion-control work, pasture furrows are now on trial under a wide variety of conditions (fig. 18). After heavy rains technicians, equipped with foot rules and soil augers, have made numerous tests to see how deeply moisture has penetrated. They have found

FIGURE 18.—Pasture furrows on a Pennsylvania hillside. Note the water standing in the furrows and the arrangement to spread water as it flows from the road culvert at the right.

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that the moisture has frequently gone from 6 to 18 inches deeper on land that is furrowed than on similar land without furrows. Frequently as much as 80 percent of a heavy rain can be held on furrowed land.

Pasture furrows are level, and they are usually constructed with an ordinary breaking plow (fig. 19). Machines are now being tested, however, which are designed to construct furrows in such a way that the existing vegetation will be disturbed as little as possible. Spacing between the furrows depends upon the steepness of slope, the cover, the soil, and other factors. Usually they are spaced at about 1- to 2-foot vertical intervals; this places the furrow from 6 to 15 feet apart, depending on the slope.

It is necessary that grass be established on the ridges and furrows as quickly as possible to prevent washing from the heavier rains that might overtop the

FIGURE 19.—Contour furrows in pastures are usually constructed with an ordinary breaking plow.

ridges. The furrow slice is prepared by harrowing and dragging, and lime, fertilizer, and manure are usually added when the ridges are seeded to hasten the growth of vegetation.

Trees

Trees have demonstrated their usefulness as soil and water conservers. In their use on project areas of the Soil Conservation Service two objectives are sought. One is to make new plantings of trees wherever they will aid in conserving soil, whether in a gully, along a fence row, or a part of an entirely new planting on land that has been converted from pasture or cultivation. The other objective is to give trees, in the present woodlands, such care and attention that they will continue to serve as soil conservers and yield a maximum income in lumber, fence posts, or fuel.

New Plantings

Except on gully-scarred areas, all new plantings of trees are made on the contour. Usually, but not always, these plantings are made in contour furrows. The furrows are made with an ordinary breaking plow and are usually spaced about 6 feet apart. The furrows help to hold additional moisture for the benefit of the young trees. Under some conditions the furrows may be a detriment. If they are not on the true contour, the impounded water may start a new gully farther down the slope. To reduce this hazard small earth dams are frequently placed across the furrows at about 100-foot intervals. Again, if the seedlings are planted in the bottom of the furrow, as they frequently are, they may have a poorer type of soil in which to grow, as the surface soil has been turned out by the plow.

In general, trees are planted about 6 feet apart each way. Normally, mixed plantings—conifers and hardwoods—are preferred. Among the advantages claimed by foresters for the mixed plantings are: The resulting leaf litter and decaying roots increase the permeability and water-holding capacity of the soil; they promote greater activity of organisms in the soil; and they provide better cover for wildlife. Furthermore, with mixed plantings, disease or insect attacks are not likely to be serious.

The ordinary plantings in the project areas in the Northeast include the following: Red, white, pitch, and Virginia pines, oaks, black locust, sugar maple, and white ash. These species are varied somewhat in accordance with the availability of planting stock and the local conditions encountered.

Black locust trees in the young forest play a role similar to clovers in a field-crop rotation. The locust tree is a legume and gathers its own nitrogen from the air. The experiment stations have called attention to the beneficial effects of black locust on other tree species. When grown together—that is, black locust and other hardwoods—there is a notable increase of growth in the other hardwoods as compared with the growth of the same species some distance away.

Since the conifers listed retain their foliage during the entire year they offer greater protection as windbreaks and shelterbelts than the hardwoods, and under average conditions they give the maximum degree of protection to the soil, and provide much-needed winter cover for wildlife.

Woodland Management

Returns from the farm woods, as is true with other crops grown, are generally in proportion to the care and management given by the owner. In this bulletin we are concerned primarily with the care of the woodland because of the permanent protection which an adequate forest cover gives to the land and to wildlife. If the woodland is made to contribute its share of profit it has a better chance of receiving continuous care and attention.

FIGURE 20.—This mature white oak tree has just been cut. Selective cutting of mature trees has been practiced in this ungrazed farm woods for several years. The soil is well protected against erosion.

If vegetation and leaf litter on the forest floor are disturbed or destroyed by fire or grazing, the soil no longer has a maximum protection. Fires frequently destroy or damage much valuable timber and the ground cover, as well as the habitat for wildlife. Under intensive grazing, the soil becomes packed and impervious to water because of trampling; the undergrowth is destroyed or impaired; weed trees are given a chance to come in; and reproduction is damaged by trampling. Controlled experiments have shown that cattle actually lose weight when confined to woodlands. Continued grazing means eventual destruction of the woodland. It follows then that one of the first steps in woodland management is the control of the archenemies of the forest—fire and overgrazing.

Farmers who become cooperators with the Soil Conservation Service in the improvement of their woodlands have two goals in view. One is to increase the proportion of the marketable species of trees, and the other is to develop a system of harvesting that gives the best returns consistent with sustained production and the conservation of water, soil, and wildlife (fig. 20). Precise methods to be used in attaining these goals vary with the conditions found in each wood lot, the soil, and market outlets. Complete information on woodlot management may be obtained from State and Federal agricultural agencies.

Gully Control

Gullies in the Northeast are so few in comparison with those in other regions that they do not shout ruin to every passerby. Extensive areas in grass and trees account in part for their absence. Then, too, bedrock or a tough impervious shale lies so near the surface in many areas that moving water can scour soil particles loose but slowly.

Up to now little has been said about treating gullies for the reason that it is wiser to remove the conditions that caused the gullies before attempting to mend the gullies themselves. Furthermore, many gullies that are now active may become stabilized naturally if control practices are placed in effect on the higher land which feeds them (fig. 21). Some gullies may become stabilized if livestock is excluded by fencing and natural revegetation thus permitted.

The aim in all gully-control work is to give vegetation an opportunity eventually to reclaim the area and make further repairs unnecessary. In treating most gullies the biggest problem is to keep water out of the channel until vegetation becomes established. Frequently it may be necessary temporarily to divert water away from the head of the gully. In preparing the area for vegetation it is often necessary to smooth down the rough banks and in the same operation place some of the better soil on the gully floor. The larger gullies may become stabilized more quickly if temporary check dams of earth, brush, native rock, and other materials are installed. After temporary check dams have been installed the whole area must be planted to trees, shrubs, vines, or grass, or a combination of these. Suitable trees probably should always be included in the selection. The plants chosen, both woody and herbaceous, should whenever possible, be selected for their value as food and cover for wildlife.

Occasionally the proximity of buildings or the value of the land may warrant the expense of costly concrete and masonry structures. When this is the case it is always desirable, if not absolutely necessary, to obtain competent engineering advice before expense is incurred.

FIGURE 21.— Gullies may become stabilized naturally if the vegetation on the watershed which lies above is improved.

The picture above shows the principal farming land on a Lancaster County, Pa., farm prior to the development of methods to control erosion. Stakes have been set to determine boundary lines for strips on the contour. Prior to the adoption of erosion-control practices the lay-out of these fields has always remained in a rectangular pattern.

In the picture below we see the altered pattern of field lay-out, two diversion terraces, and crops growing in strips across the slope on the contour. The diversion terraces, which total 1,870 feet in length, are provided with a protected outlet that safely conducts excess water to the natural channel at the extreme left. See figure 15.

Wildlife Plantings

Wildlife species can survive and multiply only when there is sufficient cover and food available (fig. 22). Erosion control and the needs of wildlife can be served in the same planting. In the planting of gully banks, farm-road banks, stream banks, the corners and sides of eroded fields, diversion-ditch outlets or spreaders, and other small odd-shaped areas wherever found, conservationists keep an eye on the needs of wildlife. In the larger areas which are devoted to new plantings of desirable trees, margins of food-producing shrubs and vines are used. Around the margin of woodland, an "edge" planting of woody vegetation will provide food and cover where most of the wildlife congregates.

Among the more common woody species which are being used in the Northeast with wildlife needs in mind are: Gray dogwood, hackberry, scrub oak, persimmon, blackhaw, American hazelnut, mapleleaf viburnum, wild plum, coralberry, bittersweet, Virginia creeper, black chokeberry, Japanese barberry, silky cornel, flowering dogwood, red-osier dogwood, thorn apple, lowbush honeysuckle, winterberry, Hall Japanese honeysuckle, wild crab apple, red mulberry, bayberry, Norway spruce, red pine, pitch pine, white pine, Virginia pine, black cherry, chokecherry, white oak, northern red oak, wild rose, American elder, European mountain-ash, snowberry, northern white cedar, hobblebush, withe rod, arrowwood, nannyberry, highbush cranberry, wild grape, and bush lespedeza.

FIGURE 22.—This ruffed grouse is well provided with natural cover.

Outposts of Cooperative Defense

IN LOOKING BACK over our agricultural record, two facts stand out boldly: (1) We have underestimated or ignored the rate of topsoil removal and the accompanying loss through erosion, and (2) we have overestimated, if we recognized any erosion at all, the value of single defense measures.

Recognition of these facts led directly to the establishment of the project areas which are located on soils representative of large agricultural regions. These project areas, selected with the advice and approval of officials representing the experiment stations, the extension services, and the colleges of agriculture, are designed to demonstrate the appropriate combination of control practices adapted to the area and to individual farms within the area.

Granting that a farmer is aware of losses caused by erosion, it is no exaggeration to say that nowhere, until the last few years, could he see how modern soil-husbandry methods could be applied in their most effective combination to his own land. A farmer in the Northeast could, for example, have taken a trip into the Southern States to see the improved broad-base terrace. He could have visited the few communities in Ohio, West Virginia, and Pennsylvania where strip cropping has been employed for many years. But nowhere could he have found the coordinated application of these and other practices upon farms similar to his own.

In the Northeast, as elsewhere in the Nation, whole watersheds are usually selected for the project demonstration areas. These areas vary in size from about 18,000 acres, at Moorestown, N. J., to 150,000 acres, at Bath, N. Y. Once an area is selected, each farmer is given an opportunity to cooperate with the Government and his neighbors in the development of control measures on his own farm. Prior to the making of any extensive plans a careful survey is made on all farms of cooperating owners to determine the extent of erosion, the past use of the land, the slope of the fields, and the characteristics of the soil.

The survey results, when assembled and interpreted, provide the basis for a control program. This program is presented to farmers; those who are suffi-

ciently interested, agree to follow definite control practices on their own farms for 5 years. The Soil Conservation Service, in turn, agrees to provide technical and a limited amount of material assistance in carrying out the program.

It must not be assumed that these programs for individual farms were hastily agreed upon. Accompanied by the farmer, technicians walked over each and every field, and they mutually decided upon a course of action. They considered cash-crop requirements and the needs for forage and pasture. The soil, steepness, and length of slope, the climate, the markets, and other factors were carefully noted. The rotations best adapted to meet these requirements were discussed and agreed upon. Plans were made for the erection of new fences and the relocation or removal of old ones so that fields could be farmed on the contour. The use of diversion ditches in connection with strip cropping and for the protection of pasture and cropland was discussed. Wood lots were to be protected against stock. Pasture treatments were planned. Severely eroded areas were to be devoted to trees or grass. In brief, each farm plan was drawn to make effective use of modern soil- and water-saving practices and at the same time to give the farmer as large an income as he had previously received, or larger.

The preceding section described the various practices, both old and new, which are now being used to curb losses induced by erosion. This section tells how these practices are now being employed by farmers cooperating with the Soil Conservation Service under conditions that apply to six different project areas. Space limitations will not permit the discussion of each of the 14 projects (see map on back cover) which are now established in the Northeast. Neither will it be possible to discuss the work being done by C. C. C. boys in camps that are attached to several of the project-demonstration areas.

Ohio—The Owl Creek Area

A line run southward from Sandusky, Ohio, on Lake Erie, would roughly mark the divide between the agriculture of the Northeast and the Middle West. To the west the Corn Belt stretches; to the east clamber the low rolling foothills of the western Appalachian Mountains. West of the line where the land flattens in Ohio, soils have been formed largely from limestone. East of that line, soils have been built principally from shales and sandstone.

The richer and more level limestone soils to the west encouraged continuous cropping, and a more speculative type of agriculture on the whole, than the more diversified farming of eastern hill farmers. Many older people now living on these undulating slopes speak of the land to the west, that may be less than an hour away by auto, as the "Plains." Merchants in border-line towns, who draw trade from both the hills and the Plains, often argue the relative merits of the two groups of farmers with whom they deal. Plains farmers more frequently ask for credit, the merchants say, than the hill farmers do.

Just east of this imaginary line, in Knox and Morrow Counties, the Soil Conservation Service has established one of its projects. It is designated as Ohio 4. This 30,500-acre strip lies between Granny and Dry Creeks, which form its upper and lower boundary lines. Both creeks flow eastward into the Kokosing River (better known as Owl Creek). Project headquarters is at Mount Vernon, the county seat of Knox County, on Owl Creek.

The few white men who entered this central Ohio wilderness in the last decade of the Eighteenth Century found that Johnny Appleseed Chapman, as was his custom, had planted apple trees in small clearings, in anticipation of their arrival. In an abandoned Indian field on the banks of Owl Creek, Chapman established one of his many small nurseries. But apart from these small clearings the whole area was thickly wooded.

When settlers in greater numbers arrived they seem to have been troubled as much by wolves as by Indians. In 1805 settlers in the "Jersey" settlement finding wolves "plenty and impudent," agreed "to give 9 bushels of corn for each wolf scalp that might be taken" and as a result "3 of the men caught 41 wolves in steel traps and pens." Deer, though not apparently troublesome, were numerous. A report of a "circular" drive, starting on the banks of Owl Creek in 1818, indicates that "from 300 to 500 deer and many wolves were bagged." In that early time a man, it is said, could step just outside his cabin door and shoot a week's supply of game.

The early settlers may not have been "water conscious" in the sense that we use the term today; yet water played an important role in their lives. Many of them arrived by boat, and when dams were built the streams provided power to grind their grain and to saw their logs. This area in Ohio was regarded as especially favorable by mill owners due to the "durability" of the streams. Yet as early as 1881 N. N. Hill, Jr., in his History of Knox County, said:

> * * * mill streams are not what they once were * * * steam is taking the place of water power. The fact is, that since timber has been cleared away and the swamps drained, the volume of water has been greatly lessened, and streams became * * * very insignificant.

Corn and wheat were the most important crops grown in this section following the removal of timber from the land. By 1880 an unmistakable trend toward more livestock was apparent. The increase in livestock was coincident with the cultivation of new soil beyond the Mississippi. More livestock on the farms and an increasing number of horses in towns and cities caused more hay and oats to be grown.

By 1900 the agriculture of the district was fairly well diversified, but further adjustments were soon to be made. Automobiles and tractors came, and the market for horse feed dwindled. During the World War grain growing was widely resumed, but this was soon followed by an expansion in dairying, due to the prospering industrial cities and better transportation facilities.

Livestock has been increased during recent years out of proportion to the carrying capacity of pastures. Because of excessive grazing and lack of manage-

ment, pastures have declined rapidly in productiveness and in their ability to protect the soil against erosion. Many of these pastures are so thin that not more than 50 percent of the soil is covered with vegetation. In an effort to increase the carrying capacity of these pastures, many of which lie on the steepest slopes, farmers have plowed and reseeded in the hope of bringing them back to productiveness. These efforts usually failed, and erosion losses increased. Furthermore the demand for pasture caused many farmers to turn their cows into woodlands where there was little forage but where much damage was done to the woods. Moreover, cropping and erosion have exhausted the fields in rotated crops to such an extent that forage crops, particularly legumes, are not being produced in sufficient quantity to feed the cattle. As a result the pasture field gates are opened too early in the spring to livestock and they are closed too late in the fall.

Practically all of the cropland and pasture land in this project area needs an application of lime. The subsoil at a depth of 4 feet or more contains plenty of lime, but this is out of the reach of most farm-crop plants. Most of the soil to a depth of 4 feet is definitely acid.

FIGURE 23.—In 1892 a sawmill stood at this spot in Knox County, Ohio. Today, almost 2 feet of topsoil covers the remains of an old slab pile. Soil was washed here from a field having a 3-percent slope.

The typical downward spiral of declining crop yields is well illustrated in this area. Farmers here started with a soil that was low in lime. Despite applications of phosphorus in commercial form and more than the average amount of manure, clover failures became more and more common owing to the absence of available lime. When clover seedings failed, the fields were usually plowed and planted to corn. Checkrow corn planters were generally used, which meant that practically every square foot of soil on these irregular sloping fields was cultivated up and down the hill. Clover was again seeded in the wheat which followed the corn, but the chances for success in obtaining a catch decreased year by year. With clover failing, the soil became less absorptive of rain

water, thus causing an increased amount of run-off and soil loss. When drought came there was insufficient moisture stored in the soil to produce profitable crops.

Erosion surveyors examined the surface soil in this area in the fall of 1935 and found that approximately 40 percent of the area has lost between 25 and 50 percent of the topsoil by sheet wash (fig. 23). Another 15 percent has lost between 50 and 75 percent, and over 75 percent of the topsoil has been lost on about 2 percent of the area. While the soil surveyors found gullies on nearly 7 percent of the area, most of them were so shallow that few farmers had difficulty in crossing them with machinery.

FIGURE 24.—The lengthening of crop rotations and strip cropping are among the major control measures being used by farmers in this project area.

Defense measures in use on the Granny and Dry Creek project represent for the most part a concerted application of proven devices to hold soil. Land too steep or too severely eroded to support an adequate grass cover is converted into a farm woods. Farm woodlands in turn are protected from livestock, and any open spots are planted to trees. Steep slopes in cultivated fields are seeded to a permanent meadow or pasture. Though most of the slopes in the area are not extremely long or steep, their unevenness and irregularity make strip cropping difficult to apply on many farms (fig. 24). Strips are used wherever possible, however, and farming operations are on the contour wherever practical (fig. 25).

Practically every farmer in the area has been attempting to follow a 3-year rotation consisting of corn, wheat, and clover or timothy. Since clover failures have been numerous the rotation, in actual practice, frequently is not of more than 2 years' duration.

The improved rotation on all of the rolling land calls for 2 or 3 years of meadow instead of 1, thus providing a 4- or 5-year interval between periods of cultivation. Yet lime seemed to be the key to the success of this rotation. All the upland soils require from 1½ to 3½ tons per acre to insure clover. When the project was started only four lime distributors could be found in the entire area,

and it is estimated that less than 5 percent of the farmers had ever used lime. While most of the farmers had been applying superphosphate for a number of years in small quantities it was apparent that larger applications were necessary. Furthermore, recent tests of 300 soil samples by the Ohio State University indicate that the available potash supply is too limited for the best plant growth.

Three steps are being taken in this area to improve the pastures. One step is to restore a portion of the lost fertility by applying at least 1½ tons of ground limestone per acre and at least 300 pounds of 20-percent superphosphate. Another step is to place furrows on the contour to catch and hold rain water for the benefit of vegetation. And still another step provides for better grazing management.

FIGURE 25.—These Ohio farm boys are having their first experience in cultivating corn on the contour.

Although soil- and water-saving operations did not start in this area until the spring of 1936, 102 farmers in two seasons made changes in practices and use of their land as shown in table 2.

TABLE 2.—*Practices adopted and changes in land use during 1936–37*

Land treatment	1936	1937
	Acres	*Acres*
Land cultivated on the contour	None	980
Cultivated land under strip cropping	do	596
Contour furrows on pasture land	do	55
Pasture land limed	Very little	430
Pasture land treated with fertilizer	do	396
Lime applied on cultivated land	do	787
Heavier than normal application of fertilizer on cropland	do	720
Woods fenced against livestock	do	995
Longer rotations used than in 1935		4,975

Between midnight June 20, 1937, and the evening of June 21 rain gages indicated that 3 inches of water fell on the Granny-Dry Creek area. Every creek and river in the area overflowed, and the result was severe loss of crops in the lowlands. Farmers on these lowlands said the water was at least a foot higher than during the flood of the preceding January.

The next morning, June 22, technicians of the Soil Conservation Service and many farmers hastened out over the land to see whether the defense measures had been effective in holding the soil. One farmer said he was not pleased with his crooked strips until after this hard rain. Another said:

> I'm well satisfied with the way the strips kept my soil from washing. If the whole field had been in corn this year it would have been full of gullies.

Another said:

> I walked over my neighbor's field where he had planted corn up and down the slope. There was a lot of soil lost between each row and the ground was hard. If you will just walk out across my strips you will see the ground is still soft.

West Virginia—The Moundsville Area

George Washington explored the upper reaches of the Ohio River in October and November 1770. He started at the point where Pittsburgh now stands and mapped his course down the river, indicating distances with plus and numeral signs at 4-mile intervals. Thus on his chart, we find +72, +76, +80, and so on to +112. His "+92" is marked just below the site now occupied by Wheeling and the "+100" appears where Moundsville now stands. This chart is reproduced in the Moundsville Echo (centennial edition) August 1935. The distances from Pittsburgh are incredibly accurate as comparison with the closely calculated river maps of today shows.

A skilled surveyor, with a keen eye for good land, Washington laid claim to Round Bottom, a West Virginia 587-acre tract (later reported as 1,293 acres) enclosed in a wide sweeping and almost circular bend of the river. This "round bottom" which appealed to Washington, and another flat area a few miles up the river, now occupied by Moundsville, lie at the western edge of the soil conservation project area which comprises 28,975 acres of land drained by Middle Grave Creek and Little Grave Creek. These two flat areas next to the river include nearly all of the level land that can be found in this part of the country.

About 1775 settlers first cleared the more gentle slopes adjacent to the river. Soon, however, demands from the down-river markets for flour and whisky induced the clearing of land all the way up to and over the hilltops, which tower 500 to 700 feet above the river. On these hills—many of them sloping over 40 feet for each 100 in distance—corn, wheat, and rye were grown for eager buyers at the river front.

In the beginning these hillside soils rewarded the pioneer with abundant crops,

but the yields were too good to last indefinitely. As early as 1840 wheat yields dropped to about 10 bushels per acre, whereas a 35-bushel yield had not been uncommon at the beginning of the century or earlier. As a result of excessive cropping and erosion, abandoned farms dotted these West Virginia hills before the prairie sod of Iowa was broken.

Within 10 years after the decline of grain farming, sheep began to appear on many of the steeper hills that were formerly under cultivation. The fine-wool sheep industry increased intensively until about 1890, as it also did over a large section of southeastern Ohio, the Panhandle of West Virginia, and southwestern Pennsylvania. An industrial boom in the Ohio Valley about 1900 caused the sheep industry to give way in part to more diversified farming; cattle raising and dairy farming appeared; truck crops came in; and practically all of the few remaining stands of saw timber were removed. Sheep, however, are still numerous. Marshall County, where the project area is located, has more sheep than any other West Virginia county. And these sheep—between 30,000 and 40,000 of them every year in Marshall County—along with cattle and dairy products, account, on an average, for about 65 percent of the cash receipts.

With the exception of the World War period, when plows again opened these slopes, the general trend in the area for 30 years has been a retreat from cultivated crops to grass and to trees. Part of this adjustment has been enforced through declining prices. Another, and perhaps a still greater part, has been due to awareness of the hazard of continuous cultivation on the steeper slopes.

A survey of 150 farms, completed in May 1937, showed that 60 percent of the crops were grown on slopes that fall less than 25 feet in 100. Only 1,022 acres in the entire project of 28,975 acres lies on slopes of 5 percent or less, and only 963 acres lies on slopes tilting between 5 and 15 percent. While 7,876 acres was found to be on slopes of between 15 and 25 percent, the bulk of the acreage, 17,405 acres, or 60 percent of the entire area, lies on slopes of 25 percent or more.

In most areas of the Northeast one looks up the slope to see erosion; here in Marshall County, one looks down. With but few exceptions, the narrow pinched valleys scarcely permit elbowroom, to say nothing of the requirements for roads and buildings (fig. 26). Consequently one finds houses, barns, gardens, and most of the cultivated land up and over the hilltops, while pasture and trees are far below.

When erosion surveyors examined the soil in this area in 1936 to determine the extent of losses through erosion they found it difficult to locate any spots where trees had not been removed. The depth of the topsoil on land that had been disturbed the least by cultivation and grazing indicated that the original surface soil had been 6 to 8 inches in depth. When these determinations were compared with surface-soil depths on cultivated land, pasture lands, and grazed woodlands, it was estimated that from 2 to 4 inches of soil had been washed from 14,366 acres, or nearly half the land in the area. On 8,246 acres it was estimated that

4 to 6 inches of soil was lost. Only 1,987 acres could be classified under the term "slight erosion," which means a loss of 2 inches or less of surface soil. On the remaining 2,648 acres it was found that all of the surface soil and part of the subsoil had been removed.

Soil losses, as estimated above, indicate clearly that soil is being lost much faster in the Moundsville area than it is being conserved under present farming conditions or rebuilt under natural processes. Even with the abandonment of farms and the reluctance of many good farmers to plow the steeper slopes, present safeguards are inadequate to stop soil losses.

FIGURE 26.—In the Moundsville area cropland is usually found on the top of the hills, while pasture and woodlands are in the narrow valleys.

The first step in developing erosion-control practices in the Moundsville area with farmers in 1936, was to get the farmers to assign more of the cultivated crops to land on gentler slopes. This was no easy task in view of the fact, as already stated, that 60 percent of the cropland now occupies slopes of 25 percent or less. In general, slopes of 25 to 40 percent were assigned to pasture and those of more than 40 percent to woods.

The prevailing rotation of crops in the area, at the time project activities were started, was corn, oats, wheat, and grass. In this rotation, cornfields were usually left bare during the winter and spring months, thus permitting severe erosion. A few farmers left wheat out of the rotation and seeded their grass mixture in the oats. There has been little success in securing good grass stands in oats, and this method is not commonly used. Perhaps the chief objections to the prevailing crop rotation from the standpoint of erosion are the lack of a cover crop following corn and the fact that most farmers leave their meadow fields in grass so many years that there is little sod to turn down when the field is plowed.

The improved cropping plan, which is now in effect on most of the farms where soil-saving practices are employed, calls for corn, wheat, and 2 years of meadow. When alfalfa is included in the meadow seedings, as it frequently is, the rotation is lengthened to 5 or 6 years. Oats, which are seldom a profitable crop in this area, have been generally dropped from the rotation. Since wheat follows corn in the rotation none of the land is left bare during the fall, winter, and spring months. Along with the improved cropping plan, fertilizer and lime treatments are recommended to insure that the rotation can be maintained on a profitable basis.

Strip cropping is used on practically every farm where erosion-control practices are employed. The steep slopes make it necessary to provide as narrow strips as are consistent with practical operations on the farm (fig. 26). The corn strips are usually one shock row in width. If corn is drilled in rows 42 inches wide this would give a shock row 42 feet in width. Occasionally a strip may contain two shock rows of corn, making the width 84 feet if the slope of the land will permit the additional width.

Diversion terraces, which now total over 15 miles in length, are used as a companion measure of control in conjunction with strip cropping. A few diversion terraces have been constructed in pasture fields.

Tree planting in this area, aside from the requirements for gully control, is usually considered from the standpoint of giving protection against erosion. Most of the trees have been planted in 30- to 50-foot bands on the steep breaks of pasture slopes. Black locust and black walnut are being used for this purpose. It is well recognized that bluegrass does well in association with black locust and it grows fairly well under black walnut.

FIGURE 27.—Valley floors comprise about 20 percent of the land area in the Cohocton River watershed.

The steep V-shaped gullies, frequently having a bottom that is a foot or less in width, require a special method of planting to insure stability. Woody vegetation, consisting of various species of close-growing shrubs and vines, is planted on the banks and along the top. All of these plants, it will be noted, serve the double purpose of stabilizing the gully and at the same time providing food and cover for wildlife.

Check dams are used in some of the gullies to assist in diverting water from the channel to a grassy area.

Pasture is the basis for the livestock industry. Yet many pastures are so badly eroded and unproductive that they provide an insufficient amount of feed. The survey of 150 farms mentioned earlier indicates that 50 to 60 percent of the pastures are capable of carrying only one animal to 6 or 8 acres. Fertilizing with 400 pounds of 20-percent superphosphate an acre and applying lime when needed, along with contour furrowing, controlled grazing, and mowing, are the principal steps taken to improve the pastures.

Although soil- and water-saving practices were not started in this area until 1936, some of the major changes effected in 2 years' time are shown in the following tabulation:

	Acres
Changes in land use:	
Cultivated area retired to permanent pasture	962
Cultivated area retired to permanent pasture and woods	309
Cultivated area retired to permanent meadow	523
Fences and other obstructions removed to permit strip cropping	185
Area strip-cropped for the first time	2,369
Pastures treated with lime and fertilizer	969
Pastures furrowed	118

New York—The Cohocton River Area

The East's largest soil- and water-conservation project is located in southwestern New York. It includes the upper watershed of the Cohocton River. The waters of the Cohocton flow in a southeasterly direction to the Chemung and thence to the Susquehanna. A great majority of the 150,000 acres included in this watershed lie in Steuben County. Approximately 10,000 acres lie in Livingston County and a few are in Yates and Ontario Counties. Headquarters for the project are at Bath.

A network of valleys, which are seldom more than 1½ miles wide, traverse the area in a northwesterly and southeasterly direction. The comparatively rich soil of the valley floors invites intensive cultivation. The uplands, comprising the long slopes and the plateaus, which tower in many places from 700 to 900 feet above the river bed, account for about 80 percent of the land area (fig. 27).

Glacial drift, of variable thickness, covers this plateau section. The surface mantle of soil is underlain with beds of shale and sandstone. The hill soils are

derived from noncalcareous glacial till, whereas the valley soils have been built chiefly from glacial outwash and post-glacial alluvium. Much of the till on perhaps 50 percent of the land area is open, friable, and well-drained, but some of it is underlain with a compact hardpan layer. Due to this variation in the character of the subsoil, there is a wide difference among the various soils in regard to moisture penetration and absorption.

Forests once covered the entire watershed; but, apart from a few swamps, practically all of the land had been cleared and brought under cultivation some time during the last 150 years. While trees have reclaimed perhaps 20 percent of the area in more recent years, the cover has frequently been impaired by fire, pasturing, and improper cutting. Some fields formerly in cultivation are now either idle or are used for pasture.

Steuben County was once the banner potato-growing county of the East. And, although potato production has steadily decreased since 1909, this crop in cash value, still leads all others in the watershed. The deep, well-drained soils on high elevation are well-adapted to potatoes and give yields that are well above the national average. For the 3 years 1929, 1930, and 1931 the hill soils yielded an average of 154 bushels an acre. Farmers who use commercial fertilizers and other improved practices frequently produce yields of more than 225 bushels an acre.

In more recent years dairy cows have come into the area to help maintain the income that was formerly derived chiefly from potatoes. Since dairy cows require large quantities of forage and pasture, this shift has been beneficial from the standpoint of erosion.

The acreage of crops in the typical rotation—potatoes or corn, oats, clover, and timothy—is not more than 35 percent of the total land acreage. Unquestionably a larger acreage devoted to crops in rotation would induce more erosion.

When clover catches fail, as they frequently do, or when the land becomes depleted through cropping so that potatoes cannot be grown profitably, many farmers resort to buckwheat for a cash crop. This crop, along with potatoes, accounts for the most serious erosion on the cultivated land. Corn, it is universally admitted, permits severe erosion, but the crop in this area is usually planted on the more level bottom lands and the acreage allotted is less than that for buckwheat.

Even though the total acreage of potatoes, buckwheat, and corn—three crops that permit severe erosion—is small in this area and there is a diversity of farm enterprises, the natural conditions impose unusual precautions. Slopes are steep. About 57 percent of the land has slopes varying between 5 and 25 percent. About 17 percent of the area has slopes varying between 25 and 35 percent. Eleven percent of the land area has slopes of over 35 percent. Usually about 53 percent of the annual rainfall comes between May and September, inclusive. Usually two or three of the summer rains are of severe intensity. When rains

such as these fall on the long steep slopes—slopes that are from three-quarters to a mile in length—soil and water losses may be severe.

When surveyors examined the topsoil on 70,722 acres in this area they found erosion apparent on all but 8.5 percent of the land area. On 34 percent of the land they found that up to 25 percent of the surface soil had been removed by erosion and on 42 percent of the area that from one-fourth to three-fourths of the topsoil had been removed. Fifteen percent of the land area showed losses of 75 percent or more of the topsoil.

In formulating a basis for erosion control on the various farms in the area, technicians of the Soil Conservation Service developed a plan of land classification based on the degree of slope. Generally on the well-drained soils sloping less than 5 percent it was thought that no protective measures would be needed. Slopes of from 5 to 25 percent could be safely cultivated if adequate protection was given; slopes of between 25 and 35 percent required grass or trees, and slopes of more than 35 percent could safely be planted in trees only.

One of the urgent problems in the area was to find desirable cover crops to occupy the land after potatoes and buckwheat had been harvested. Smooth and Russet Rural types of potatoes are normally grown. These varieties mature so late in the fall that rye cannot be sown early enough to attain sufficient growth for adequate cover. A few farmers in the project area have planted a part of their crop to early-maturing varieties such as Chippewa and Katahdin. These varieties can normally be harvested early enough so that rye seeded immediately afterwards can make sufficient growth for protection. Moreover, this plan aids in the distribution of labor. The plan is still on trial, but the results to date warrant a wider adoption of the practice.

No crop grown in the area leaves the soil so loose and vulnerable to erosion as does buckwheat (fig. 28). Like potatoes, the crop is harvested late in the fall, thus giving no opportunity for a cover crop to develop sufficiently to prevent soil losses if the crop is seeded after the buckwheat is harvested.

The seeding of rye with buckwheat is a plan under trial. About 1 bushel of buckwheat to 1½ or 2 bushels of rye is seeded per acre, the usual rate of seeding if each crop were to be grown separately. If the crop receives favorable rains during the few weeks prior to the buckwheat harvest the rye survives well and by winter may reach a height of 6 to 8 inches. The following year the crop may be plowed down as green manure or allowed to mature as grain.

Farmers in the Bath project area tread on a narrow safety zone when using lime. If too much lime is used, the potatoes are likely to be scabby. If no lime is used, clover failures become more and more common, as practically all soils in the project must have lime to insure success in obtaining clover. In recent years some farmers have applied too much lime, and their results have tended to discredit its use in more moderate amounts. It is clear now that

lime in a quantity sufficient to grow red clover can be applied without harmful results.

To make it possible to convert the steeper slopes now in cultivation to permanent grass, it was apparent at the outset that if the farm income was to be maintained or increased, more dependence must be placed upon the hay crop in the rotation. And to make the hay crop successful, legumes must be grown in greater quantities. This invariably means the use of lime and phosphorus. Local deposits of marl have been made available to farmers in the area. The Soil Conservation Service has demonstrated methods of excavation and successful spreading of the marl which offers considerable promise as a satisfactory local source of lime. This marl has from 85 to 95 percent of total carbonates.

FIGURE 28.—Buckwheat and potatoes are two crops that permit severe erosion in the Cohocton River area. The picture above shows a poor arrangement of strips. Buckwheat was planted immediately below the strip of potatoes. One rain did most of this damage.

Practically all of the pasture land in the area needs treatment to secure a sward that will provide protection against erosion and more feed for livestock. Each step in the pasture-improvement program is directed toward the reestablishment of wild white clover. Lime is applied in sufficient quantity to permit the growth of red clover. Phosphorus equivalent to 800 pounds of 16-percent superphosphate is applied to each acre. After 4 or 5 years lime and phosphorus are again applied as needed. Rotation grazing and the clipping of weeds are equally important features in the improvement of these pastures. Methods of improvement have been demonstrated on approximately 1,060 acres of pasture land. Farmers on land adjoining the project have applied these prac-

tices on many times this number of acres. Contour furrowing of pasture land is under trial. It is not yet known whether contour furrows will increase the carrying capacity of a pasture sufficiently to warrant their general use. It is believed, however, they have a real place on the pastures with the poorest swards, where every aid is needed in alleviating drought conditions, and particularly on slopes with a southern exposure.

Contour farming as an erosion-control practice appealed to many farmers from the beginning. This was the case, perhaps, because many farmers have been accustomed to plowing and cultivating across the slopes. However, most of this cultivation across the slopes has not been close enough to the contour to prevent soil loss.

Strip cropping has proved to be one of the major practices adaptable to the district. When strips were laid off on many of the farms in 1935, a few farmers were reluctant to have them follow the contour as closely as recommended. They believed, at the time, that the variable width of the strips and the crooked rows would make farming operations difficult. Strips on the true contour, they learned, after one season's trial, were much more effective than those in the laying out of which considerable deviation was permitted. As a result many of these farmers in 1937 requested that every strip boundary be placed on the absolute contour even at the sacrifice of an even-width strip. By February 1, 1938, 10,630 acres had been planned for strip cropping, which included two-thirds of all the rotated cropland on the farms operated by cooperating farmers. Most of the remaining one-third was on gently rolling or flat land which did not need the protection that strip cropping offers.

Diversion terraces may almost be considered a companion measure to strip cropping as a method of preventing soil loss in this area. This type of structure has been found to be especially useful in preventing water from the poorly drained upland soils from running down over well-drained land devoted to strip crops. On long slopes, several of these terraces may be constructed in connection with strip cropping in order to break the slope and reduce the large concentrations of water. These structures are designed to handle the water from rains of maximum intensity, which may be expected to occur about once in 10 years. Although engineers and agronomists believe there are refinements and improvements yet to be made in the diversion terraces, their usefulness has been proved in this area. In 1935, 749 lineal feet of diversion terrace structures were built on the project, and by 1937 there were 80,468 feet in operation. The drought of 1936, and the resulting loss of many seedings on outlets, made it necessary to sod many spots in the spring of 1937.

Farm woods comprise approximately one-fifth of the project area. With isolated exceptions the farm woods have declined in their usefulness as soil conservers. In general, this decline has been caused by unwise management, such as grazing and injudicious cutting for fuel and lumber. With the cover impaired

on the woodlands, which lie, for the most part, on the steepest slopes—many on slopes of more than 50 percent—an increasing amount of water rushes from these formerly well-protected areas and frequently flows down over pasture and cultivated fields to the detriment of both.

On 204 farms improvement plots have been laid off to demonstrate the proper methods of selection and cutting (fig. 29). These plots total 512 acres and are located in farm woods that total 5,304 acres.

Approximately 7,000 acres of farm woods are now protected from grazing livestock. These lands were unprotected prior to the establishment of the project area in 1935.

Tree planting on the slopes to be retired from pasture or cultivated lands has been confined principally to the following species: Red pine, Norway spruce, black locust, white pine, and red oak. During the 2-year period 1936–37 trees were planted on 2,526.3 acres and on 298 farms. Extreme drought conditions during 1936 made it necessary to replant many trees the following year. Including the newly planted acreage of trees and that of the farm woods protected from grazing, there are now approximately 10,000 acres of woodland on a substantial basis of control.

Figure 29.—Selective cutting of timber has been demonstrated on plots which total 512 acres. These plots are located in farm woods that total 5,304 acres.

Although the project has been in operation only 2 years, 307 farmers are working out a complete program of soil and water defense for their land. These 307 farmers operate 39,514 acres, and 21,058 of these acres are now under treatment with erosion-control practices. Treatment has been completed on 15,750 acres.

Pennsylvania—The Lancaster Area

One of the Northeast's most extensive belts of soil developed over limestone swings down across southeastern Pennsylvania and northern Maryland. It crosses the Potomac in the vicinity of Harpers Ferry, where the mouth of the Shenandoah marks the northern extremity of Virginia's famous valley. During the first flush of settlement, about 1700, the Germans, the Swiss, the Scotch-Irish, the Welsh, and the English swept over this limestone pathway. All were inclined to seek land similar to that which they knew most intimately in the Old World. Influenced by an ancient aversion to "dry" limestone lands, many of the first comers, particularly the Scotch-Irish, later sold out to Germans and went on. They preferred the slaty hills where they found pure springs of water near the surface.

The first of the Germans went no farther than the limestone lands of Penn's domain which appeared so similar to those of their homeland in the Rhine Valley. And they looked with particular favor upon a somewhat detached and half-hidden limestone zone in York and Lancaster Counties.

This area early gained a reputation for its productivity. And later, when the colonists were engaged in the Revolution, it was to this area and other sections nearby that Washington looked for the salvation of the patriot's cause. On May 28, 1780, to Joseph Reed, he wrote: "Either Pennsylvania must give us all the aid we ask of her or we can undertake nothing * * * the fate of these States hangs upon it."

After approximately 200 years of continuous occupation by the white man this area probably is in as high a state of preservation as any long-established agricultural section on the continent. Part of this preservation can be attributed to the natural productive capacity of the soil, part to the permanency and skill of the management, and part perhaps to the diversity of products made possible by the diversity of markets.

Though soil losses have not yet caused general concern in Lancaster County there is ample evidence that damage occurs every year on some of the most productive soils. Water from one heavy rain during the summer of 1937 washed many tons of soil onto the Old Philadelphia Pike 8 miles east of Lancaster. This soil was carried through a newly etched gully in a clover field that lies on a 3-percent slope. But back of the clover field, on this particular watershed, 80 acres had been planted to corn, and much of the silt originated there.

Though most of the soils in Lancaster County originated from limestone, the soils in the project area were derived chiefly from gneiss, schist, and quartzite. This project lies in the watershed of West Octoraro Creek. The summary of the erosion survey indicates that 86 percent of the area has been affected by sheet erosion; 73 percent has lost more than one-fourth of the topsoil; and 14 percent of the area suffers from gully erosion in various stages of development.

On the whole, and through the years, there has been a fair balance between the cropland and the land devoted to pasture and timber. Farms in the area today contain an approximate average of 115 acres per farm. These 115 acres are apportioned approximately as follows: Woods 15; pasture 15; cropped land 80; and roads, buildings, and farmsteads 5. Yet on these 80 acres of cropped land only 35 are normally devoted to corn, potatoes, tobacco, and other intertilled crops. Moreover, practically all of the corn and oats and much of the wheat is fed to livestock on the farm. Manure applied to the land has helped to maintain fertility and resistance against the wash of rains.

FIGURE 30.—When this dam was destroyed by heavy rains in 1934 the water washed out a V-shaped channel into a deposit of silt 11 feet deep.

Though these soils have received better than average care, judged by prevailing standards, natural conditions in the area impose severe handicaps. The land elevation varies from a low of 240 feet above sea level to a high of 920 feet above. The average rainfall of 42 inches annually, 30 of which falls during the growing season, on these slopes make it necessary to provide additional safeguards to prevent soil loss.

The dams of many abandoned mills which were formerly driven by water power reveal losses of soil from the watersheds above them. Kings Mill, on Kings Run, was built more than a century ago. In 1934 water from heavy rains washed out the dam above the mill. Water pouring through the break, etched out a V-shaped channel into a deposit of silt 11 feet deep (fig. 30). This silt was piled to the very brink of the old spillway. The richest soil in the deposit,

engineers found when examining the channel, lay at the bottom, while soil nearer the top was poorer and more sandy. The engineers calculated that this small dam, through the years, had backed up approximately 27,000 tons of topsoil. The V-shaped cut alone accounted for some 7,250 tons of soil. Of the 1,200 acres in this small watershed, approximately 75 percent is cultivated farm land.

The crop rotation generally practiced in the project area includes corn the first year. In the second year, tobacco, silage corn, tomatoes, or another cultivated crop may be grown. In the fall of the second year wheat is usually seeded, and this crop is followed by 1 or 2 years of hay. Occasionally wheat may follow wheat a second year.

Much of the erosion on the steeper cropland can be attributed to the use of two cultivated crops in succession and the fact that no cover crop has been grown following the first crop of corn. To improve this rotation, from the standpoint of erosion control, a few farmers cooperating in the project, are now seeding biennial sweetclover after the last cultivation of corn or rye after the corn is harvested. If the slope is very steep the rotation is shortened to include but 1 year of a cultivated crop. Combinations of the various common grasses are on trial as cover crops for seeding at the last cultivation of corn. The primary purpose is to provide a cover that is resistant to erosion. A secondary consideration is the amount of organic matter produced for turning under.

Since much of the wheat is sown after corn has been cut, it frequently does not attain sufficient growth to resist erosion. Service cooperators are making an effort to get the wheat seeded earlier. Timothy sown in the fall improves the cover during winter. Legumes seeded in the spring further enhance the effectiveness of the cover. Winter barley rather than wheat is being sown the second year of small grains by some farmers. This crop normally produces a very good cover before freezing weather.

In addition to the soil losses mentioned above as being caused by two intertilled crops in succession, perhaps the next most serious losses in the past have been caused by plowing a whole sloping field and growing an intertilled crop. Strip cropping effectively checks the loss in these fields, and many farmers believe that by its use they have received higher crop yields because of the increased amount of moisture which was available during droughty periods in the growing season. On farms under agreement, with slopes of 6 to 15 percent, strips of cultivated crops are now protected with alternate strips of wheat or hay. Strips are normally about 100 feet wide, although on a few farms where the slopes are more gentle they may be as much as 125 feet in width. By February 1, 1938, 2,220 acres in the project area had been planned for strip cropping. (See illustration in the center of bulletin.)

On fields under cultivation that slope less than 12 percent the standard broad-base terrace (fig. 14) has been found useful. These structures, which total 23 miles in length, are now in operation on 14 farms. Diversion terraces have been

found beneficial on cultivated slopes of from 12 to 30 percent. These structures, now in operation on 20 farms, are built with a terracing outfit and are usually spaced from 200 to 400 feet apart; the average spacing being about 300 feet. On July 5, 1937, over 4 inches of rain fell in 22 hours. This was the first severe storm, locally referred to as the "big rain," which tested both the terraces and the diversion terraces.

Treatment of pastures in the area usually involves one or more of the following steps: Applications of lime and phosphorus; contour furrowing; mowing of weeds; and controlled grazing. To date 41 acres of pasture on 10 farms have been contour-furrowed.

Treatment of woodlands involves the fencing out of livestock, the planting of small steep areas that were formerly in cultivation or pasture, and the selective cutting of timber to afford a sustained yield of lumber, fuel, and fence posts.

Practically all of the soils (Chester, Manor, Edgemont) in the project area were low in lime in their virgin condition. Through the years, leaching, cropping, and erosion have further reduced the supply to such an extent that lime must be applied on many fields to insure an adequate growth of legumes. Limestone of high quality (97 to 99 percent of total carbonates) can be found in the county, although much of this is not readily accessible to farmers in the project area. The Soil Conservation Service has demonstrated how some of the lime of lower quality (80 percent total carbonates), which is more accessible, can be prepared economically for local use. If a particular field needs an application of 2 tons of the lime of average quality, 2½ tons of the lower quality lime is recommended.

New Jersey—The Pensauken Creek Area

One of the three New Jersey soil and water conservation projects lies just east of Camden and is in sight of the higher buildings in Philadelphia. Approximately 80 percent of the project area is in Burlington County and 20 percent is in Camden County. Where the northern boundary of the area crosses the Pensauken Creek the land elevation is about 10 feet above tidewater. From this level it rises to a general elevation of 70 to 100 feet.

Except for villages and wet land along streams which have been left in timber, the area of 17,980 acres is in farms, of which 12,672 acres are used for cropping purposes; the rest being in pasture, woodland, and idle land. About 48 percent of the acreage, 8,676 acres, is devoted to tomatoes, peppers, cabbage, melons, and various other vegetables. One-fifth of the area is devoted to fruit, principally apples and peaches.

In the days of the horse, New York, Philadelphia, and other cities on the eastern seaboard used steam-drawn scows and flat cars to remove manure from the city to the land (figs. 31 and 32). South New Jersey Coastal Plain vegetable and fruit growers could pay good prices for this manure, and most of it came to their land.

FIGURE 31.—Unloading manure from a scow in 1912.

FIGURE 32.—Unloading manure from the streets of New York City, on the Coastal Plain of New Jersey.

When motor vehicles so largely replaced the horse, Coastal Plain soils were deprived of this source of natural replenishment. Since that time vegetable and fruit growers have relied chiefly on plant food from commercial sources. But the organic matter, which makes manure most valuable, has not been available in commercial form at a price farmers can pay. Furthermore, the general exodus of the horse from the cities all but destroyed the market for hay, with the result that grass appears very infrequently in the rotation of crops.

Realizing their need for organic matter, many farmers in late years have sown fall cover crops to partially replace the supply that was once available from the city. But the intense cropping system imposed by high land valuations, and the

lack of livestock to consume forage crops made it impossible to maintain the organic matter in sufficient quantity. Paradoxically, it seemed that the farmer could not afford to grow his organic matter, and neither could he afford to be without it.

Most of the soils on this Coastal Plain area are sandy loams or loamy sands. These soils require large quantities of organic matter to knit them together and make them more absorptive to rain. Moreover, organic matter tends to disappear more rapidly than in most soils owing to the intense cultivation and heavy applications of fertilizer. Many farmers use winter cover crops to help maintain the supply of organic matter. The cover crop, however, is usually poor, because of the late plowing of the land in the fall and early plowing in the spring. Many of the vegetable crops leave small residues, and in some cases both the roots and leaves of such crops are sold, as with carrots and beets.

Because of the inadequate humus content of the soil; because of a type of farming—double cropping in many cases—that leaves the soil bare to the elements for a greater part of the year, and because of the light texture of the soil, it is not uncommon to find severe cases of erosion where the land slopes 3 feet or less in 100 feet of distance. Farmers have stood out in pouring rains with technicians of the Soil Conservation Service and watched soil moving off spinach fields onto strawberry plants in a field with slope that is barely perceptible.

The casual observer or one who expects to find erosion losses only on land with a decided slope may pass this Coastal Plain section by with unconcern. Yet when soil surveyors mapped this project area and examined the depth of surface soil they estimated that losses ranged from zero to 25 percent on 73 percent of the land. And they found that from 25 to 75 percent of the original soil had been removed from another 16 percent of the land. These figures have additional significance when it is realized that 95 percent of the land has slopes of 5 percent or less.

Strip cropping, here as elsewhere, is a practical method of erosion control. To conform, however, with the conditions imposed by an intensive vegetable cropping plan, various adaptations are necessary. Different methods are now on trial. The method most commonly used involves the laying of contour lines with parallel cultivated strips 50 to 100 feet wide, depending on the slope. Contour lines are laid out with a maximum deviation of 0.5 percent. Below this cultivated strip another contour line is run but allowing for at least a 20-foot width at the narrowest point between the lower contour line and the last row of cultivated strip above. This leaves an irregular or compensating area between each cultivated strip and the next contour. Generally this area is sown to grain or permanent hay. By reversing the area in cultivation and laying the rows parallel to the lower contour, advantage is taken of the organic matter developed through the grass residues. Point rows in the cultivated strip are eliminated, although in some fields sharply curved rows may result.

The use of broad-base terraces has proved to be a practical and effective method of erosion control on vegetable farms (figs. 33 and 34).

FIGURE 33.—This field, on the Coastal Plain of southern New Jersey, slopes but 3 percent yet heavy rains caused severe sheet wash and damage to the crop of spinach in 1936.

FIGURE 34.—This is the same field as shown in figure 33. Terraces and contour cultivation have reduced soil losses and crop damage.

In the Orchard

Years ago, most of the orchards, both apple and peach orchards, were clean-cultivated. Absence of any vegetation was indicative of superior farming. This clean cultivation, along with the depletion of organic matter in the soil and the fact that most orchards are on sloping land, accounts for much of the erosion in orchards. Moreover, numerous trips through the orchards with heavy spray machinery, frequently up and down the slope, left depressions that rapidly formed into gullies.

In more recent years the clean cultivation of apples has been discouraged. Although it is now an accepted practice to cultivate peaches in both directions during the growing season, cover crops remain on the land the remainder of the year. Cooperators with the Soil Conservation Service generally cultivate across the slope, and only when necessary will they cultivate up and down the slope. If cultivation both ways is necessary, the first cultivation is up and down the slope, and the second and last is across the slope so that the ridges left by the cultivator or disk will aid in the control of erosion. Wheat, rye, and a mixture of vetch and crimson clover are the winter cover crops that are generally used. Of the three, the mixture of vetch and crimson clover is preferred both for the cultural advantages and increased control of erosion. Its advantage for erosion control lies in the fact that it can be left longer in the spring. Under normal conditions this cover is disked in between April 15 and May 15, depending upon the adequacy of the soil moisture to supply both the trees and the cover. A new winter cover is again sown between August 15 and September 1. The other covers, wheat and rye, are usually disked in earlier than the vetch and crimson clover, and their seeding can be delayed until later in the fall.

In general, the practice of using clean tillage with seasonal cover crops applies to apple orchards much the same as to peach orchards. There has been a distinct trend, however, toward the use of a permanent cover crop in the apple orchards. At the present time alfalfa is the most favored crop. Soil conservationists believe that alfalfa alone is not the most satisfactory cover. In orchards under agreement, a mixture of alfalfa or sweetclover with grasses is used where erosion conditions are hazardous. These crops are mowed at the time when it appears that they are beginning to deprive the trees of needed moisture.

A method which might be considered a compromise between clean tillage and a permanent cover is now being tried in the project area, and early results are promising. Under this plan the alternate middles are placed under a leguminous and grass cover. Plantings of leguminous and grass covers are made across the major slope, and to adapt the practice for erosion control these alternate strips may be run on the diagonal. Even a herringbone pattern may be chosen if the slope of the land makes that practice most feasible (fig. 35). This system, it will be noted, practically places half of the orchard in strips.

When it is impossible to secure an adequate growth of a cover crop or to use contour methods for erosion control, mulching offers the best substitute. No method used in the project area has given better results. Though too early to draw definite conclusions, it now appears that mulching of the alternate middles will give effective control. Silt carried by water over mulched areas, it has been observed, is usually deposited before it has gone 10 feet. For this reason it is believed that mulching of half the area will be sufficient for erosion control.

For mulching purposes such materials as cornstalks, straw, salt hay, and even weeds may be used. A minimum of 5 tons per acre is considered necessary for

the initial application, and the equivalent of from 1 to 2 tons per acre must be applied annually thereafter to maintain an adequate depth of mulch.

Cost of the mulching material and the fire hazard during dry weather have prevented its wider use. The fire hazard is minimized when the mulch is used only on the alternate middles, as described above. The fire hazard, however, is negligible after the mulch has become packed by orchard traffic and made moist by rains. Recurrently, storms and high tides from the Atlantic deposit considerable quantities of salt hay along the right-of-way of highways at certain points. Through arrangements made with the New Jersey State Highway Commission, much of this salt hay has been made available for mulching purposes.

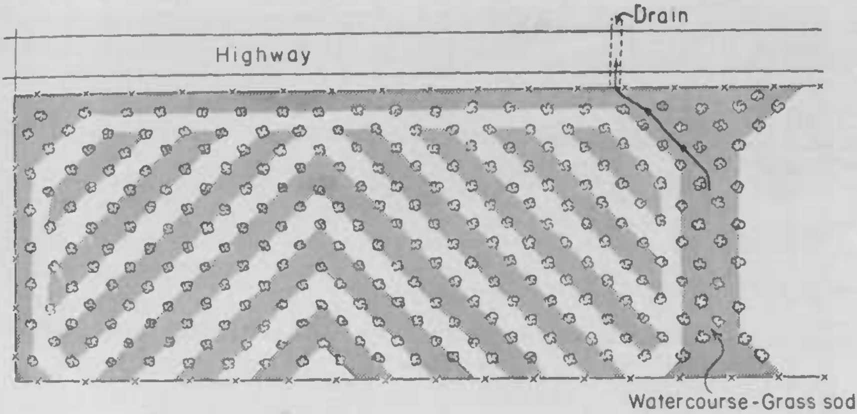

FIGURE 35.—A herringbone pattern of alternate seeded strips with clean tillage has been developed in this New Jersey orchard.

In 1907 M. B. Waite built terraces and planted a peach orchard on the contour on his farm in Prince Georges County, Md. About the same time Charles E. Bryan, of Harford County, Md., planted an apple orchard on the contour. His orchard lay on a 40-percent slope. In time, movement of soil toward the trees by cultivation shaped bench-like terraces along the contour lines made by the rows of trees. Throughout the Northeast these two mature orchards offer practically the only time-tested examples of the effectiveness of contour planting and terracing that can be found. New plantings now being made by cooperators with the Soil Conservation Service are on the contour if there is any real slope to the land. Terraces are constructed on most of these proposed orchard sites before the actual planting is done.

In the construction of terraces for a proposed peacn orchard, engineers for the Soil Conservation Service keep in mind that the conservation and uniform distribution of moisture will be beneficial in addition to the soil that is saved. Wherever possible, and for the same reason, a terrace for each row of trees is favored (fig. 36). In order to conserve as much moisture as possible and because

the construction and maintenance of outlets are expensive, especially on the steeper slopes, level terraces are used whenever soil conditions permit and where the chances of success are favorable.

The horizontal distance between terraces and tree rows in proposed peach orchards usually varies between 20 and 25 feet. These terraces are small when compared with the standard broad-base terrace used under field conditions. At present terraces that have a cross section of about 5 square feet are favored. By moving all of the earth from the upper side, on slopes of up to 10 percent, these structures can usually be completed by making two and one-half or three rounds with an 8-foot or a 10-foot blade terracer.

FIGURE 36.—Air view of a peach orchard planted on small orchard terraces. Note the spur rows.

In the case of apple orchards a horizontal spacing of 40 feet, with a correspondingly larger channel cross section, is generally recommended. The reason for this recommendation is that the usual distance between tree rows in a mature apple orchard is 40 feet. Sometimes the apple orchards are interplanted with peach trees, which usually die about the time thinning operations become necessary in an apple orchard; or, apple trees are planted in rows 20 to 25 feet apart, and alternate rows are removed after the trees reach such size that it is impossible to work between them. In such cases terraces should be constructed for every row of trees in order to distribute the moisture supply equally. From an erosion-control standpoint this is not important where orchards are kept in permanent sod.

Terrace spacings vary to conform to the slope of the land. When this space equals the width of two tree middles a spur or short row of trees can be provided. In some cases several spur rows of varying length can be planted between terraces. If the spur rows cannot be cultivated conveniently, they can be mulched.

While terraces or diversion ditches may be constructed in established orchards, this procedure almost always necessitates the removal of an excessive number of trees, and the maintenance of the terraces is more difficult than where trees are planted on the terrace ridges. The number of trees to remove in a peach orchard (spaced 20 to 25 feet apart) is greater than the number in mature apple orchards, where the rows are 40 feet apart. The number of trees to remove for terracing is usually between 8 and 15 percent. In most places it is impossible to cultivate parallel to the terraces if they are constructed after the trees have become established on the square-planting system. In apple orchards it is usually possible to establish a permanent sod, but even so, there is a possibility of damaging the terrace ridge in spraying operations and the removal of fruit.

In old orchards where active gullies are present and terracing is impossible, effective results are frequently obtained by the use of temporary check dams. These structures are located in tree rows and do not interfere with cultivation across the slope. Wire dams are usually favored, although other materials may be used. Care must be taken that a well-laid brush or rock apron is provided, so that serious erosion will not be caused by the overfalling action of water. Areas protected by these check dams are vegetated and maintained as sodded waterways.

Maine—The Aroostook Area

Aroostook County, Maine, roughly equals the land area in the State of Massachusetts. It is Maine's most northern county and the East's last frontier. Though by 1900 the principal waves of land occupation had stopped at the shores of the Pacific, settlement was still underway in the woods of northern Maine. Today in Aroostook it is not uncommon to find men in their fifties who ride tractors over soil they themselves have stripped of its primeval forest cover. And although timber cutting has dwindled in late years, potatoes are still claiming the land against the trees. Potato acreage expanded from 85,000 acres in 1920 to 133,500 in 1934.

The railroad from Bangor did not strike through until 1895. The expanding and extensive potato industry dates from then. The crop rose from 2 million bushels in 1890 to 6 million bushels in 1900 (fig. 37). In 1910 it was 17 million bushels, and in 1920 it was 21 million bushels; by 1930 it was 41 million, and by 1935 it was 46 million.

If this area is approached from the south by auto, one must drive 130 miles north from Bangor (at least 60 of them through the woods) to reach the potato country. There, spread before one is a gently rolling countryside, fringed on

the west by the forest wall and on the east by the Canadian border. The bulk of the potato crop is grown in a narrow strip from one to three townships wide, little more than a speck on the map in fact; yet from this area rolls forth about one-ninth of the potato crop of the United States.

The climate and soil of this northland country provide a natural habitat for the potato. Applied science, as reflected in the control of diseases, the improvement of varieties, the increased application of commercial fertilizers, has pushed average yields far above those of any other State in the Union. But it is not science, solely, that has pushed up yields. As in all new parts of the country, worn-down land has been traded for new; and the virgin soil taken

FIGURE 37.—The Aroostook potato acreage rose from 85,000 acres in 1920 to 133,500 acres in 1934.

has yielded robustly for a while. With yields rising, scientists as well as farmers have been inclined to overlook visual evidences of soil erosion. Muddy water in the rivers, piles of silt on the highways, and small growing gullies through potato fields, have caused no general concern. Unless the gullies became so deep that farm machinery could not be driven across them they were considered little more than an annoyance.

While many growers have made commendable progress in combining legumes, small grain, and grass crops along with the intertilled crop of potatoes, the proportion of these on the whole, and through the years, has been small.

Snow covers the land, as a rule, from November until late in March, and it is protected from erosion at least 6 months of the year. Yet potatoes provide scant summer cover; and since most of the crop is planted in rows up and down the long slopes, soil and water losses are heavy.

Though this land is not old in terms of the years it has been in cultivation, intense cropping has brought soil problems more quickly than in most areas.

Potatoes are heavy feeders upon plant nutrients, and Aroostook farmers early learned that yields could be maintained or increased by using commercial fertilizers. The old standard application, in vogue for years, was about 2,000 to 2,500 pounds of a 4-8-7 or a 4-8-10 fertilizer to the acre. More recently applications have tended to increase, but yields on many of the earlier-tilled soils fail to respond as they once did.

Growing potatoes on the same soil year after year will, of necessity, reduce and gradually exhaust the supply of organic matter, thus making the soil less absorptive to water. One of the visible effects is an increase in soil erosion.

Many of the more alert growers have recognized that the organic-matter supply must be maintained or increased. Red and alsike clover, when plowed under as a green-manure crop, seemed to meet this need, for clover failures were relatively uncommon prior to 1920. In 1924 Verne C. Beverly, the county agricultural agent, noted that red clover failures were rather general throughout the county, and the loss was attributed to an infestation of black army cutworms. The following year clover failures were again common, but there were few cutworms. Hence cutworms were not wholly to blame. That year Beverly made a large number of tests to determine the acidity of the soil. He found many soils too acid to permit the growth of clovers.

A. K. Gardner, crops specialist for the extension service at the University of Maine, states that probably less than 200 tons of lime were used in Aroostook County prior to 1925. But it was from these scattered farms where lime was applied that the county agent discovered many good clover stands. At the time, the belief was prevalent that lime could not safely be used on potato land because lime would promote the development of scab. It might be possible, Beverly reasoned, that a small amount of lime—enough to permit clover growth—could be applied without inducing scab. Eighteen farmers applied about 200 tons of lime in 1926. The results were favorable, and by 1934 over 8,000 tons of lime were applied on Aroostook farms. In the 5-year period 1927–31 successful clover catches were recorded on 89.7 percent of the demonstration plots, as compared with 25.3 percent on check plots where no lime was used. Meanwhile, in 1928, the Maine Agricultural Experiment Station started tests to determine how much lime should be applied. Their results show, that as a general rule, 1,000 pounds of high-analysis and finely ground limestone or hydrated lime will be sufficient for a good catch of clover, without inducing scab, even when the soil is strongly acid. This Station introduced crimson clover in 1929, and by 1934 over 8,000 acres were grown in the county.

Nature, through her normal processes, provided Aroostook County with a thick mantle of soil material. While several different soils occur in Aroostook the one which predominates is known as the Caribou loam. It is characterized by its reddish brown color. While the subsoil is relative-thick in comparison with the topsoil the entire profile to bedrock will not average over 4 to 5 feet in

depth. In many cases the ledge is very close to the surface and outcrops as hummocks or bare spots. Even so, if a potato grower had the opportunity of compounding an ideal soil for potatoes he could scarcely improve on this soil of Aroostook County.

This surface soil is sour or acid enough to prevent the growth of scab organisms. Aroostook potatoes grow bright and clean. The soil becomes less acid as one goes deeper and at 20 inches conditions are favorable for scab. At 24 inches conditions are still more favorable for scab because the soil contains larger quantities of calcareous or limey materials than the soil in the upper layer.

If sheet erosion is permitted to reduce the depth of the surface soil, the time will come (indeed it has arrived for a few fields) when the plowshares will break through into the subsoil that is more favorable for scab development. Today on farms that have been in cultivation for less than 20 or 30 years it is not uncommon to find whole fields retired permanently to hay or pasture because the land became so thin and ledgy that it was no longer profitable to cultivate. If this ledge contains enough free lime "scabby" land will develop.

The 30,000-acre project in Aroostook County, designated as project No. 1, is the first demonstration in Maine to be conducted by the Soil Conservation Service. It is in fact the first in New England. Roughly triangular in shape, the area is bounded on two sides by the Aroostook River, a part of which leads from Presque Isle to Caribou and then in a hairpin turn leads toward Fort Fairfield. The lower border is determined by the highway leading from Fort Fairfield through Maple Grove back to Presque Isle. Within this area are approximately 250 farms of from 50 to 600 acres each.

When the project was established in 1936 soil surveyors made a study of nine farms within the area to determine the extent of erosion. Of the 1,831 cultivated acres in these nine farms, the surveyors found that 1,247 acres were damaged by sheet erosion labeled "moderate to severe"; 359 acres were declared "severely eroded;" and on only 222 acres could the erosion be called "slight."

During the same year Joseph Chucka, head of the soils department at the Maine College of Agriculture, supervised a similar survey, though more extensive, covering 40 farms scattered throughout the potato-growing sections of the State. These 40 farms contained 3,443 acres. Only 47 acres revealed little or no erosion. It was found that 881 acres had lost less than 25 percent of the surface soil. From 2,290 acres, or about 66 percent of the total acreage, 25 to 75 percent of the surface soil had been lost. Seventy-five percent or more of the surface soil had been removed from 67 acres. From the remaining 158 acres, all of the surface soil and a large amount of subsoil were gone, and only a shallow cover over the bedrock was left.

If it is assumed that the original surface soil on these 3,443 acres was 12 inches deep, 3 inches or less of the topsoil has been removed from 881 acres; 3 to 6 inches of soil from 2,290 acres; 6 to 9 inches of soil from 67 acres, and all the topsoil and a large amount of subsoil from the remaining 158 acres.

Logically the first step in developing an erosion-control program was to reshape fields and boundary lines to harmonize with the slope of the land so that contour cultivation could be employed (fig. 38). One of the difficulties encountered in doing this had its inception when the land was first occupied. Many of the first settlers obtained much of their holdings through squatters' rights. "Broad shoulders and personality," it is said, frequently determined how much frontage each settler would have along the Aroostook River. And it was generally assumed that each squatter was entitled to land a "long ways back" and up from the river front. Though later divisions and additions have reshaped the original pattern of boundary lines, one still finds numerous farms that are long and

FIGURE 38.—Many fields in Aroostook County have been cultivated up and down the long slopes, thus permitting water to rush to the rivers unimpeded.

narrow. One farm, on which an erosion-control program is now in effect, is 43 rods wide and extends a mile back and up on a slope of more than 10 percent on an average.

The erosion-control measures which have been given the most emphasis in the Aroostook area are contour cultivation, strip cropping, and a rotation of crops that will increase the supply of organic matter in the soil and at the same time give a better balance in the crop acreage.

The strip-cropping plan is based on a 3-, 4-, or 5-year rotation, and it is so arranged that the strips in potatoes are separated by the strips in hay or grain. When possible, the 3-year rotation of potatoes, grain, and hay is used to hasten the accumulation of organic matter. In some instances, however, when steep land is being converted to permanent sod it is necessary to use on the remaining cropland a 4-year rotation consisting of potatoes, potatoes, grain, and hay to obtain enough acreage in potatoes to provide an adequate cash income. In the

event that little hay is required, practically the entire crop of hay may be plowed under for green manure.

Width of the strips in general is determined by soil type, slope, and the extent of erosion in a particular field. Aroostook soils normally are more absorptive of rainfall than are the soils in many other areas; and since potatoes are ridged in hills 8 to 12 inches in depth, it is possible to use wider strips than those in use elsewhere. Few strips are less than 150 feet wide; a few are as much as 350.

Normally snow does not leave the land early enough to permit spring plowing prior to the planting season. For this reason fall plowing is customary. Some farmers who have sod strips to plow will leave a narrow buffer strip until spring.

FIGURE 39.—This natural waterway was seeded in the spring of 1937 after potatoes had been planted.

During the spring thaw this buffer strip spreads and checks the flow of water. It takes little time in the spring to plow this buffer area prior to the preparation of the entire strip for planting.

Natural depressions or drainageways in all strip-cropped or cultivated fields are retired to permanent sod, and tillage implements are raised when crossing them (fig. 39).

Terraces, the first in New England, are under trial on a few farms. When these terraces were being designed, engineers kept in mind the machinery which farmers are now using. Structures in use so far have been placed on comparatively even sloping land. At present, at least, it is not expected that terraces will be advocated for rough land or steep slopes.

On fields where considerable erosion is taking place and terraces are not appli-

cable, diversion terraces (fig. 16) have been used. For both diversion terraces and terraces, adequate outlets must be provided for the concentrated water. In Aroostook County it is usually possible to find a well-sodded pasture or a forested area where this water may be safely discharged. If not, provisions are always made to care for this water by constructing outlets.

Numerous check dams have been constructed in gullies to prevent further cutting. Most of these dams are of the temporary type and are designed to check the flow of water until vegetation can be established. Material available locally such as rock, wire, and logs have been used most frequently.

The following tabulation reveals some of the major changes which have been effected on 56 farms in the area, where a cooperative program has been in effect. These changes in land use were effected as of December 31, 1937.

	Acres
Total area of 56 farms	8, 122
Total cropland	4, 725
Approved rotations	4, 725
Contour strip cropping	2, 804
Field strips	1, 500
Land retired permanently to hay	338

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